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Education Department Bulletin

Published fortnightly by the University of the State of New York

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No. 473 ALBANY, N. Y. JUNE 15, 1910

New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 140

SIXTH REPORT OF THE DIRECTOR OF THE SCIENCE DIVISION

INCLUDING THE

63D REPORT OF THE STATE MUSEUM, THE 29TH REPORT OF THE STATE GEOLOGIST, AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1909

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New York State Education Department
Science Division, February 15, 1910

Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I communicate to you herewith for publication as a bulletin of the State Museum, the *Sixth Annual Report of the Director of the Science Division* for the fiscal year ending September 30, 1909.

Very respectfully
JOHN M. CLARKE
Director

State of New York
Education Department
COMMISSIONER'S ROOM

Approved for publication this 21st day of February 1910

Commissioner of Education

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DIRECTOR'S REPORT FOR 1909

INTRODUCTION

This report covers all divisions of the scientific work under the charge of the Education Department and concerns the progress made therein during the fiscal year 1908–9. It constitutes the 63d annual report of the State Museum and is introductory to all the scientific memoirs, bulletins and other publications issued from this office during the year mentioned.

Under the action of the Regents of the University (April 26, 1904) the work of the Science Division is "under the immediate supervision of the Commissioner of Education," and the advisory committee of the Board of Regents of the University having the affairs of this division in charge are the Honorables: T. Guilford Smith LL.D., Buffalo; Daniel Beach LL.D., Watkins; Lucian L. Shedden LL.D., Plattsburg.

The subjects to be presented in this report are considered under the following chapters:

I Condition of the scientific collections
II Report on the Geological Survey, including the work of the State Geologist and Paleontologist, of the Mineralogist, and that in Industrial Geology
III Report of the State Botanist
IV Report of the State Entomologist
V Report on the Zoology section
VI Report on the Archeology section
VII Publications of the year
VIII Staff of the Science Division and State Museum
IX Accessions to the collections
X Appendixes (to be continued in subsequent volumes). All the scientific publications of the year

I

CONDITION OF THE SCIENTIFIC COLLECTIONS CONSTITUTING THE STATE MUSEUM

Since my last report some changes have been necessitated in the location of the collections of the museum, all of which present locations are to be regarded as wholly temporary while awaiting transference to the Education Building. Some displacement from old locations has been necessary to accommodate the demands of the Commissioner of Agriculture for increased room in the Geological Hall. Giving way to these requirements has resulted in again dispersing parts of the collections of the Geological Hall into other buildings in the city of Albany and has involved the Department in serious expenditures for rental and maintenance of new quarters. An inevitable disquietude has resulted from these invasions which has been somewhat increased by the preparation necessary for final removal and instalment of all the collections and the progress of new undertakings requiring additional working room.

At the present time the collections of the State Museum are distributed as follows:

1 Geological Hall. In this building there still remain the offices of the Assistant State Geologist and his staff; of the Mineralogist, and some part of the collections in geology, paleontology and mineralogy; the seismograph is also installed here; also the offices of the State Botanist, with the botanical collections constituting the State her-

barium; of the State Entomologist with the collections pertaining thereto; of the Zoologist, with all collections in zoology except for instances otherwise specified; workrooms of the taxidermist and archeologist.

2 State Hall. The rooms occupied in this building are the offices of the Director and State Geologist with his immediate staff, together with the extensive collections in paleontology and some others of value. These collections are in drawers and in preparation for removal.

3 Capitol. The corridors of the fourth floor contain on display a very considerable collection in archeology, though only a fraction of such material as is in our custody. In these corridors also are a few cases of mineralogic, paleontologic and ceramic exhibits. On the sixth floor of this building are 100 drawers of minerals and certain large relief maps. In the safe in the Cashier's office, Education Department are the archives of the Iroquois Nation consisting of wampum belts and other articles of historical importance.

4 McCredie Malthouse. This is the general storehouse for all the collections and equipment of the museum which have been displaced by the recent invasions of the Geological Hall or for which no other place can be found. About 500 cases of specimens are here stored.

5 Universalist Church. This building, situated at the corner of Swan and Jay streets, has been rented at the expense of this division and is being utilized as a studio for the artist engaged in preparing the very large background scenery for the Iroquois collection and as office and workroom for the Archeologist.

6 State Normal College. In the corridors of one of the western buildings is temporarily placed, by courtesy of the president, a large, newly mounted group of black bears.

7 Property of J. L. Verstrepen, Delaware street, Albany. Here is a series of large geological specimens which are being removed as opportunity affords.

8 Flint Granite Company, Cemetery Station. At this place, 3 miles north of Albany, is stored a large and unique slab of trails from the Potsdam sandstone, weighing upward of 20 tons.

To this record of 8 widely separated locations in the city of Albany is to be added the fact that there are in storage and under insurance, awaiting transportation whenever accommodations here

permit, several large mounted groups of mammals (moose, buffalo and others) in charge of the Ward Natural Science Establishment at Rochester.

This much divided and scattered condition of the work is profoundly embarrassing and involves serious loss in concentration of effort and of time and enjoins arduous and exacting conditions. Yet it may be regarded as making for progress, as it certainly is now unavoidable in preparing for the equipment of a new museum.

This situation has not been allowed to interfere with the progress of the proper scientific investigations of this division, which have taken the direction indicated herewith.

II

REPORT ON THE GEOLOGICAL SURVEY, INCLUDING THE WORK OF THE STATE GEOLOGIST AND PALEONTOLOGIST, OF THE MINERALOGIST AND THAT ON INDUSTRIAL GEOLOGY

GEOLOGICAL SURVEY

Areal geology

In the progress of the survey directed toward the execution of the geological map of the State on the topographic scale of 1 mile to 1 inch, a considerable number of topographic quadrangles have been completed and published, with full explanatory details of geological structure. In addition to the completed quadrangles a variety of special maps have been issued in connection with particular geological problems, some of the older of these maps being on such geographic base of approximate accuracy as was best available, but all special maps of later years, whether they have covered limited areas, completed county areas or a series of counties, have been based on the topographic unit.

A list of all geologic maps of the State, of every description, was published in my report of last year, and the number was there shown to be large, 329 entries being recorded. I append here a list designed to indicate only the complete quadrangle maps which have been made with special reference to the systematic execution of the State map. In this list the terms starred indicate maps now in press.

*Alexandria Bay (Cushing)
Amsterdam (Prosser & Cumings)
Auburn (Luther)
Buffalo (Luther)
Canandaigua (Clarke & Luther)
*Cape Vincent (Ruedemann)
*Clayton (Cushing & Ruedemann)
*Elizabethtown (Kemp)
Elmira (Clarke & Luther)
Genoa (Luther)
*Grindstone Island (Cushing & Smyth)
Hammondsport (Luther)
Hempstead (Woodworth)
Little Falls (Cushing)
Long Lake (Cushing)
Mooers (Woodworth)
Naples (Clarke & Luther)
Nunda (Clarke & Luther)
Olean (Glenn)
Ontario Beach (Hartnagel)
Ovid (Luther)
Oyster Bay (Woodworth)
Penn Yan (Luther)
Portage (Clarke & Luther)
*Port Henry (Kemp & Ruedemann)
Port Leyden (Miller)
Remsen (Miller)
Rochester (Hartnagel)
Salamanca (Glenn)
*Theresa (Cushing & Ruedemann)
Tully (Luther)
Watkins (Clarke & Luther)

In addition to these, reports have been rendered to the Director on the quadrangles listed below, these awaiting publication chiefly for completion in certain details.

Cazenovia
Chittenango
Morrisville
Syracuse

Central and western New York. In western New York final resurvey has been made by Mr Luther of the Caledonia, Honeoye, Wayland and Phelps quadrangles and preliminary control of the Batavia, Attica and Depew quadrangles with an expansion of operations of previous years on the Albion, Medina and Lockport regions. These results represent in part the gradual summation of work extending over several seasons and the progressive attack on new fields.

In central New York the Utica quadrangle was covered in a preliminary control by Mr Clark and work on the Sangerfield quadrangle progressed by Mr Whitnall.

Eastern New York, *Saratoga county.* Saratoga Springs has, for several years, been the seat of a litigious activity in which the welfare of the mineral water and gas springs is involved, with deep concern to a variety of commercial interests. By virtue of recent legislation the State has set itself to save the mineral water springs. It is a worthy but difficult task; worthy, because the Saratoga springs present a unique geological phenomenon which should be saved from destruction, irrespective of the commercial interests involved; difficult, because the intervention of government has come late and is confronted by large vested rights.

With regard to the adjudication of important issues now in the courts and arising from the situation at Saratoga, the State Geologist can have nothing to say, but he can and desires to emphasize the fact that the relations of the mineral springs to each other and to the gas springs are a strictly geological problem. These relations must be understood before any determination of intelligent modes of reclamation can be hoped for, and should be comprehended before any readjustment of recognized rights in the properties involved is attempted. This geological problem is not an easy one. No such problem, deeply buried out of sight and reached only by the drill, is easy. There is probably no place where the subterranean conditions at Saratoga are paralleled and the obscurity of their interrelations makes the problem of the source and durability of the waters, their salinity and their pressures one of difficult reach, but the analyses can not be prosecuted by any other mode of attack than the geological.

The Saratoga springs have been a fruitful source of theories and vagaries by casual geologists, chemists, mineralogists and hydrographers, which are so frequently contradictory and have been so often exploited, as to weaken confidence in most of the solutions proposed. So often have favored contentions for and against one or another exposition of the conditions been promulgated from the witness stand and elsewhere that the present situation leaves everything to be desired in regard to exact knowledge as a basis of procedure on the part of the State, if the Saratoga springs are to be effectively protected.

With full realization of the seriousness of the problem there presented and of its difficulties, the State Geologist organized a resurvey of the Saratoga springs region during the past season. This survey was, of compulsion, confined to a review of the surface structures of the country. It was fully understood that such an undertaking, unsupported by the drill, must be inadequate in its results, for in a subterranean problem the drill is the geologist's finger. Appropriations, however, were wanting to carry on this extensive but essential part of the work. The records of the many commercial wells put down at Saratoga are lost or inaccessible, and no conclusions of the problem can be reached and no proper procedure for the conservation of the springs be deduced until redrilling over the extensive area has been carefully executed.

The field work of the season was not, however, without good results in its bearing on the problems at issue and the survey of

the Saratoga quadrangle carried on by Drs Cushing and Ruedemann will be continued and concluded by being brought into connection with the survey of the Broadalbin quadrangle by W. J. Miller.

Referring specially to the field determinations made in this work, certain stratigraphic details have been perfected.

The limestone of the Mohawk valley, which has heretofore been classed as "Beekmantown," proves to be composed of two unconformable members, the upper, comprising the so called "fucoidal beds," a limestone of lower Beekmantown age, and the name *Tribes Hill limestone* has been proposed for it; the lower is of dolomite, is older than the Beekmantown, and the name *Little Falls dolomite* is restricted to this member. The upper formation thins westward and disappears just west of Little Falls.

In the eastern part of the Mohawk valley the Potsdam sandstone appears beneath the Little Falls dolomite, grading up into it through a series of passage beds, the two plainly belonging to the same formation. At Saratoga the basal portion of the Little Falls dolomite becomes locally a fossiliferous limestone, which has been provisionally termed the *Hoyt limestone*. Over it the Little Falls dolomite, but the true Beekmantown seems to be absent, the Trenton limestone resting on the Little Falls dolomite. Traced through Whitehall to Ticonderoga the latter is found to be directly equivalent to Division A of the Beekmantown division which lies unconformably beneath the remainder of the Beekmantown and does not belong with it but with the Potsdam and passage beds between.

On the Broadalbin quadrangle in Fulton and Saratoga counties, the area comprises rocks of Precambric, Paleozoic and Pleistocene ages.

The Precambric rocks cover about one third of the quadrangle and are chiefly represented by the Grenville schists with which are associated younger foliated syenite and porphyritic granite as well as nonfoliated dikes of gabbro or diabase. The remainder of the area is occupied by Paleozoic formations including the Potsdam, Little Falls, Trenton, Utica and Lorraine formations.

Of the Precambric rocks the Grenville, in several distinct areas, is by far the most common, one area alone occupying more than 40 square miles. Belts of very pure quartzite are at times found in the Grenville. The syenite and granite are highly

metamorphosed, the syenite commonly appearing almost schistose.

The true Beekmantown appears to be absent from the Broadalbin quadrangle so that the Trenton always rests unconformably upon the Little Falls dolomite. A series of distinctly transitional beds lies between the Potsdam sandstone and the Little Falls dolomite. This formation has been named from the town of Galway where it is best shown and it has been separately shown on the geologic map. Toward the southeast the Potsdam has at its base a very interesting conglomerate made up of Grenville quartzite fragments from 1 to 3 feet in diameter.

The district is remarkable for its faults, no less than 14 having been mapped. They are all normal with displacements ranging from 100 to 150 feet. Several of these have been mapped for the first time, and one of these, the *Batchellerville fault*, showing a displacement of 1500 feet, has been traced for over 10 miles. The Batchellerville fault is also of interest because, so far as known, it is the greatest of the Mohawk valley faults with the upthrow side on the east.

Pleistocene deposits of various types are finely exhibited. There is distinct evidence, as shown by A. P. Brigham, that a current of ice flowing south-southwestward past Northville met another current flowing northwestward past Galway in the vicinity of Broadalbin. The lowest land, including the area of the great swamp known as the "Vly," was once covered by a glacial lake.

Adirondacks. Last year I reported the completion of the survey of the Elizabethtown and Port Henry quadrangles by Professor Kemp and Dr Ruedemann and this report is now in press. Professor Kemp has followed this by the survey of the Mt Marcy quadrangle which lies next west. The field work had been done upon the area in former years and the final report had been to some degree blocked out.

This section of the Adirondacks contains many points of special interest. The two summits, Mt Marcy and Mt McIntyre, which alone of all the peaks exceed 5000 feet, are within it. Of the 16 peaks which stand between 4000 and 5000 feet, 14 are also here. The remaining two are Giant, which lies just east, and Whiteface which is a few miles north. It will thus be readily seen that we are here dealing with the culmination of the Adirondacks.

Careful study of the mountains brings out the fact that in the

large way the ridges trend northeast and southwest, yet this general structural feature is modified by two broad north and south valleys, of which the larger, the famous "Keene valley," contains the chief settlements and the smaller is marked by Elk lake. These latter valleys are believed to be old topographic depressions which have antedated the northeast and southwest faults, the causes of the later ridges.

The northwestern portion of the quadrangle is occupied by a great gravel flat standing at approximately the 2000 foot contour and much cut up by the streams. Over at least 10 square miles of area, no bed rock exposure is visible and one is forced to conclude that some relatively wide and open valley has been buried by the gravels which were incidental to the waning glacial period.

The postglacial deposits and the moraines of the ice period itself have done much to modify the relief and rearrange the drainage. There is good evidence of a lake that must have been impounded by some barrier on the north and that filled the Keene valley during the closing of the glacial period. The gravelly deltas along the sides of the valley admit of no other interpretation and in the case of the terrace on which the Willey House stands just beyond the northeast corner of the quadrangle, the amount of gravel is so great as to be very impressive.

There is little doubt that in the preglacial times the area around the Upper Ausable lake drained off to the southwest through the Boreas river and that drift has changed the old order of things. The present divide is in a swampy area and is scarcely 20 feet high.

There are many precipitous mountain fronts which usually trend northeast and southwest and afford beautiful scenery. In the narrow passes at their feet lakes may be situated, such as the Cascade lakes, the Lower Ausable, and Avalanche. Some of the mountains are also sharp and narrow in their summits, as in the case of the Gothics. Others, like Marcy, are rounded and dome-shaped.

The hard rock geology is similar to other Adirondack quadrangles, already described in the bulletins of the State Museum. The oldest rocks are the Grenville sediments which are well shown in the Keene valley. Except for one small patch, apparently caught up in the anorthosites just south of the Cascade lakes, they do not appear outside this depression. They may, however, lie buried beneath the gravels of North Elba and also of the Elk Lake basin.

The rocks next in age are the anorthosites, which cover almost all the quadrangle. They are its characteristic rock and constitute all the high peaks but one. The blue labradorite rock, sometimes giving opalescent colors in the brooks, is almost universal. The syenite series enters from the north and in a variety that is transitional to the anorthosites constitutes Pitchoff mountain. The syenites soon fail, however, and the anorthosites take their place.

The anorthosites are cut by a number of intrusive masses of basic gabbro, of which the wonderful dike at Avalanche lake is a striking example. It runs from the lake to the summit of the ridge, cleaving two mountains apart like a wedge.

There are numerous basaltic dikes which favor the northeasterly fault cracks.

The intrusive anorthosites have wrought some contact effects upon the old Grenville limestones which are among the best illustrations of these phenomena yet noted in the Adirondacks. The limestones have been changed in one locality to masses of red garnet and green pyroxene, and in another have a body of magnetite much mixed up with garnet and other contact minerals. The ore body was mined to some extent in the old days of the forges but is now idle. It is the only ore deposit worthy of mention yet found in the quadrangle. The great predominance of the anorthosites would lead us to anticipate only titaniferous ores outside of the Grenville area.

Mineral wealth is thus lacking. The entertainment of summer visitors and the lumber business are the chief means of support of the inhabitants.

Southeastern New York. In my report of last year reference was made to *cooperative undertakings with the New York City Board of Water Supply,* with reference to the assembling of the geological data recorded in that great engineering enterprise. During the year past, Dr Berkey has brought together from these sources and from independent surveys of the contiguous territory, begun before this form of cooperation was effected, the general summary of new knowledge in the form of a bulletin which has been submitted for publication. In the preparation of this bulletin the immediate object has been to place in convenient form an outline of the present understanding of the geology of the region and to discuss facts gathered in this extensive exploratory work carried on along the course of the Catskill aqueduct, with special reference to the geological structures on Man-

hattan island. The task has proven a difficult one. It has been found necessary to summarize the data and give results rather than to present the whole mass of facts. The final outcome will be the solution of a series of problems very largely in the form they have presented themselves to the practical engineer and others working on them. The bulletin therefore falls readily into the line of applied geology and it is believed will have distinctive educational use in that field.

Detailed study of old drill borings in New York city has led to the opinion that the present conception of the areal and structural geology of Manhattan island and the East river needs considerable correction. This, however, applies only to the southern portion under heavy drift cover. The tunnel developments of the city make details of this sort of much importance. Instead of the island being wholly Manhattan schist, the data seemed to require that at least two narrow belts of the Inwood limestone and Fordham gneiss should extend through the lower east side. Explorations designed to test this theory have proven it to be true. Limestone does not follow the East river continuously. A large area of grano-diorite cuts through the gneisses in Long Island City and Brooklyn and crosses the East river into Manhattan. A corrected map of this section will be published in the bulletin.

The exceptional advantages offered by tunnels now being constructed throughout the Highlands region along the aqueduct makes it possible to see the prominence of some structural features that are otherwise obscure. Faults and crush zones and other effects of movement are surprisingly numerous. They are in all stages between complete recementation and complete decay. Some of the older are in as good physical condition as the original wall rock, others of later origin are reduced to clay or similar incoherent matter to great depth. In at least one such case on Manhattan island, complete decay extends to a depth of over 300 feet.

Additional exploration on the Hudson river indicates clearly that there has been glacial widening of the preglacial gorge at the Storm King entrance to the Highlands and that there is probably also glacial overdeepening. Borings in the channel have penetrated silts, sands and drift to a depth of – 674 feet at which point it is now believed rock bottom has been encountered.

Further detailed field observations tend to confirm the opinion previously given that metamorphosed sediments constitute the most ancient rock types of this region and that they are the equivalents of the Grenville series as known in the Adirondacks.

Work on the *Poughkeepsie quadrangle* has been carried forward by Prof. C. H. Gordon, who reports as follows:

Precambric. Some portions of the gneissic areas were reviewed with care. It has seemed entirely possible to establish the identity of the rocks which make up the narrow strip that extends from the carpet mills at Wolcottville northeastward to Vly mountain with the gneisses of the Fishkill mountains. This strip, which will be referred to as the Glenham belt, was described by Mather as the "Matteawan granite."

The rocks which make up its major portion vary from greenish granitic types of rather massive character to more gneissoid and usually somewhat finer grained rocks with reddish color. The primary minerals composing these two varieties are quite similar and are quartz, microcline or orthoclase, plagioclase and biotite. The last named has undergone alteration which appears to be an ancient character. During the period of this alteration the biotite was more or less completely changed to chlorite and considerable quantities of iron oxids were liberated. Occasionally the granitic rock passes into a type with scarcely any ferromagnesian minerals, with milky quartz and a feldspar pink from disseminated iron particles. These varieties grade into one another although the greenish rock is most abundant in the southern end of the strip and the gneissoid type around Vly mountain. The varieties just described are those which have been emphasized by most observers and have been called "altered sandstone," "bastard granite," etc.

Within the last two or three years new cuts have been opened in this strip in the process of evening up the grade on the road from Fishkill village to Wappinger Falls. This road cuts the strip about midway of its length. Among the rock varieties exposed in these cuts are hornblende and micaceous gneisses quite similar to some of those seen in the Fishkill mountains and several varieties of altered gneissic derivatives. Epidote is abundant in many outcrops.

It has proved possible to trace in a satisfactory manner the rocks composing this strip through somewhat similar masses lying at the south in Matteawan to the base of the Fishkill mountains. Rocks identical with the altered and epidotic gneisses

and greenish and gneissoid rocks of this strip were found in the eastern part of the town of Matteawan. Certain easily marked faults have broken the areal continuity of the whole.

The Glenham belt near Vly mountain shows a small patch of the quartzite. In Matteawan a considerable knoll of the basal quartzite is preserved between Anderson, Grove and Walcott streets near "Rock hollow." The Precambric age of these masses is thus indicated. The Glenham belt and the smaller masses at the south are interpreted as inliers of the older rocks. The Glenham belt is a faulted inlier. The others are probably such. The rocks which make up the larger part of these inliers are looked upon as altered derivatives of the gneisses. They belong to the same general epoch as the quartzite, that of the transgressing Cambric sea. Their present compact condition is due to the same metamorphic processes that changed the basal sandstone to a quartzite and the overlying limestones and slate to their present condition.

At Hortontown, a small hamlet in the Highlands south of Shenandoah, a basic eruptive made up chiefly of hornblende and magnetite, with some pyroxene, is in close association with a quartzite, entirely similar to the basal quartzite and of considerable extent, and with a few scattered ledges of an altered rock made up of magnetite and bastite. The relations are very obscure. The presence of a clear fault along the eastern base of Shenandoah mountain seems to permit the interpretation that the eruptive is of Postcambric age and that it has penetrated the basal Paleozoics and altered the ferruginous dolomite without materially affecting the refractory quartzite. Most of the altered limestone has been removed.

Cambric. The discovery of the opercula of Hyolithellus micans Billings in the bluish gray limestones overlying the basal quartzite at the base of the Fishkill mountains during the previous years, indicated that fossils in the quartzite would probably be found in the neighborhood, and a slab of compact quartzite with the surfaces covered with brachiopod and trilobite fragments has been found in the yard of Ward Ladue in the West Fishkill Hook district south of Johnsville. This find led to a persistent search for the quartzite in place. A few weeks later the fossils were found about ½ mile to the south. The locality may be reached by taking the east road into the mountain from the West Hook, passing the house of Ward Ladue as far as Herman Adams's

house, and then by following the gully east of the road for two or three hundred yards. The ledge occurs on the east of the gully about 3 or 4 feet below the base of a stone wall that separates the gully from an old orchard on the east. The fossils occur in the hard compact quartzite similar to that in Ladue's yard, but are most numerous in the thinner, somewhat friable rusty layers just beneath. The compact rock shows dull imperfect surface markings and numerous rusty spots when broken. The friable layers show great numbers of fragments including brachiopods resembling Obolella and the spines and cheeks of trilobites identified as Olenellus sp.?).

The basal quartzite passes conformably into a bluish gray fossiliferous limestone in the orchard of Ward Ladue and north of here on the farm of William L. Ladue the limestone grades upward into calcareous shale thus giving a conformable series of Lower Cambric strata. Just what the relation of the limestone further north is to this series, it is very difficult to determine. The Lower Cambric is probably faulted up into younger limestones.

Wappinger limestone. This formation occurs within the quadrangle in two well defined masses: the composite Wappinger creek belt and the Fishkill limestone.

A portion of the former was reexamined during the past summer for the purpose of learning more about the cherty dolomitic limestone overlying the arenaceous beds carrying Lingulepsis cf. pinniformis in the western strip of this composite belt. Apparently the latter beds grade up into the dolomitic rock. The latter does not appear to bear much resemblance to the so called "Calciferous" of the central strip of this belt as developed at the type locality at Rochdale. Passing westward along the Spackenkill road from the Albany post-road one crosses the gently inclined or horizontal Upper Cambric beds at points near Ruppert's farmhouse and just a little east of this place, and then over very different cherty strata without fossils in which the stratification and dip are not distinct. The two, however, appear to be in conformity. Near Camelot station the arenaceous Potsdam beds appear pitching to the southward and south of here at the Clinton Point Stone Company's quarry at Stoneco are strata very similar to the cherty beds just described, with westward dip and such general position as to indicate that if continued northward they would have a position with reference to the Upper Cambric like that

occupied by the cherty beds along the Spackenkill road. The thick masses in the Stoneco quarry have not yielded fossils. It seems that within this western strip there is a considerable thickness of heavy dolomitic limestones lying above the Upper Cambric fossiliferous beds which are older than the Beekmantown ("Calciferous," Rochdale group). Whether this mass belongs with the Cambric of the Canadian group could not be determined, nor the question of whether deposition was continuous from one period to the other.

During the seasons of 1908 and 1909 a number of new cuts were opened in the Fishkill limestone in the process of constructing the State road from Fishkill Landing to Beekman. These were examined with considerable care, but except for one or two doubtful cases, no fossils were discovered. A mile west of East Fishkill ("Gayhead") a slightly distorted impression with form suggesting some member of the Strophomenidae was found on the freshly broken rock. All shell characters were absent, although the form was reasonably distinct.

Fossils which could be recognized have been discovered in this limestone along its western margin, in the Lower Cambric horizon, as above described, and in one instance along its northern margin near Hopewell. Elsewhere they have not been found either on fresh surfaces or in weathered outcrops.

The slate formation is almost completely eroded from this limestone mass. There is reason for thinking that much of the limestone is older than the Trenton and perhaps of Cambric or early Ordovicic age.

Hudson River slate formation. A careful examination of many outcrops in this formation has added only one new fossil locality. This occurs at a hamlet known as Swartoutville, about 2½ miles north of Brinckerhoff. The fossiliferous ledges were discovered while tracing the limestone boundary. On the farm of Irving Hitchcock at Swartoutville, about three or four hundred yards west of the road from Brinckerhoff to Hopewell Junction, is a high knoll made up of gray limy shales with interbedded limestones. The shales contain Plectambonites sericeus and other fossil fragments. These beds are regarded as lying near the base of the slate formation and as of probable Trenton age. The beds appear structurally to belong with the limestone which is faulted against the presumably younger slates on the west.

Considerable interest attaches to the discovery of several small, usually conglomeratic, limestone patches within this formation. Three of these occur near Arthursburg north of

Hopewell Junction and three somewhat larger ones east of Pleasant Valley. All appear to be brought up by faults within the slates. Several are marked by a limestone conglomerate entirely similar to the Trenton conglomerate of the Wappinger creek belt and Solenopora compacta was noted in the most western masses. These patches are now exposed because of greater thrust at the points where they now lie along extensive thrust lines. The conglomerate is often overlain by a silicious lime-sand rock which is followed by the slate formation. As far as it goes the evidence would appear to show that at the east the lime-mud rock with fossils shown at Pleasant Valley, Rochdale and at Sleight's farm near Manchester Bridge gives way to this coarser silicious sand rock. Close folding and probable thrusting have brought these two phases of contemporaneous deposition into closer areal relations than they had originally.

It seems likely that the epoch of limestone formation during the Trenton transgression within this quadrangle was of short duration. Much of the slate is probably of Trenton age.

Surficial geology

Some reference has already been made to these features in Saratoga county and additional work was done on the general field of the lower Mohawk valley region over the Broadalbin, Gloversville, Amsterdam and Fonda quadrangles by Professor Brigham. This continued field work has brought to an essential completion the classification and distribution of the surface deposits in this region and the necessary maps and report have been rendered. Extension of this survey was carried into the area north of Gloversville, a district belonging to the southern Adirondack forest and lying in the towns of Mayfield, Bleecker and Garoga in Fulton county, and including the southern parts of Benson and Arietta in Herkimer county.

The region is rugged, in large part wooded and attains a maximum altitude in Pinnacle mountain, of 2514 feet. Many other elevations approximate this altitude. The valleys and slopes are covered with a massive and fairly constant mantle of glacial drift. Rock outcrops are frequent, but the average thickness of the drift is large. Distinctly morainic accumulations are, however, not important though some low hills of this nature occur about Bleecker, Bleecker Center and Lindsley Corners. Lakes and ponds are numerous, and belong in the main to the glacial blockade type, though it would often be hazardous to affirm that glacial erosion did not enter as a component factor.

The chief interest from the point of view of the glacial geology is in the direction of the striae, records of this nature being found in about 24 localities. It is known that the movement a few miles to the south, about Gloversville and Johnstown, was westward, while the latest movement on the east, or about Northville, was southward. The average movement in the district now studied proved to be southwest, showing that the higher grounds, well into the southern Adirondacks, felt the influence of the great westward movement up the Mohawk valley. The direct southward flow at Northville seems to have been late and in the control of the local trend of the Sacandaga valley. The top of the Pinnacle, on account of weathering, does not show distinct gravings, but the molding shows clearly a southwest trend. One mile north of Rockwood, on the edge of the Lassellsville quadrangle, the striae even show a direction of w. 20°–25° n. So at Wheelerville, near Canada lake, and by Middle Stink lake, also on the Lassellsville area, readings are approximately west. Aqueo-glacial drift was very nearly absent, the chief exception being in some interesting glacial terraces about Bleecker Center.

The further extension of these Mohawk glacial waters was studied in a broad way by Professor Fairchild from Taberg in the Ontario basin to Coxsackie in the Hudson valley. The work was partly in review of critical localities and partly new mapping of the glacio-lacustrine features.

It was found that a series of glacial stream channels lie along the west side of the Hudson valley, in continuation of the stream flow across the northeast face of the Helderberg scarp.

Special problems

Clinton formation. The value of this term in the geological nomenclature of America has been a matter of some general interest and discussion and as the term is an historic one, based on a rock section at and near the village of Clinton, the significance of the name and its proper definition may be briefly referred to. It would be a matter of slender and local importance if this rock series and the fauna it contains were confined to the State of New York, but as the division was early established by the New York geologists and the formation extends very widely beyond the boundaries of the State, northeast, southwest along the Appalachians, and broadly through the west and northwest, its definition assumes an importance of some magnitude.

The Clinton formation was first called, by Vanuxem, the Protean group, on account of the variable character of its sediments and their colors. When, soon after, the geographic term *Clinton* was substituted for the formation, it was based on the rock section referred to at Clinton village, its lower limit being recognized as bounded by the Medina sandstone there present, but its upper limit being undefined, or in other words, the entire section there exposed above the Medina formation being left as the exponent of the Clinton formation. In the Genesee valley the Clinton term was also recognized and used contemporaneously by Hall. There the formation is much more advantageously and completely expressed, and over it lies without interruption a bed of gray shale which was separately designated by Hall as the *Rochester shale.*

Our knowledge of the fauna of the Clinton unit, as well as of the Rochester shale, has been essentially derived from the Genesee section. With the progress of knowledge it is satisfactorily determined that at the Clinton section at Clinton is a weak development of the Rochester shale and this was included by inference in Vanuxem's definition of the Clinton formation.

In actual date of establishment the term Rochester shale is older than Clinton, but only the work of later years has shown the presence of the earlier named formation in the "type" section of the latter. The question has, from these acknowledged conditions, arisen in this form: Shall the Clinton formation be made to include the deposits and fauna of the Rochester shale?

In New York we have felt disposed to hold the view that the early geologists, of course totally unaware of the sharp and precise requirements of an advanced knowledge, employed formational terms with some degree of elasticity, even of laxity, and in the particular case in hand, that the rock succession in the Genesee valley is a truer demonstration of actual relationships and its early denominations a more faithful expression of successive geological events than either section or names in the Clinton section. It seems to us doubtful whether ancient and loosely defined names can wisely be resuscitated, in defiance of advances in knowledge, or whether such attempts at resuscitation are not virtually new definitions, thus lacking wholly the merit claimed for their age.

The stratigraphic contrast in these two sections is very pronounced. In the Rochester or Genesee river section the Clinton

beds from below are as follows: (1) Sodus shale, (2) Furnaceville ore, (3) Wolcott limestone, (4) Williamson shale, (5) Irondequoit limestone. In the Clinton section no entirely satisfactory division of the strata has yet been made. How far the divisions of the Rochester section can be correlated with or applied to the Clinton section is still to be determined, but they now seem to have little in common. The Wolcott limestone is certainly not repeated in the section at Clinton, and the presence and extent of the other divisions can be determined only by careful study of the intervening area.

At Clinton there is an important stratigraphic and faunal break at the top of the green shale overlying the lower or oolitic ore bed. The shale is here overlain by heavy limestones showing traces of ore and 9 feet higher is the upper ore or red flux bed.

The fauna of this section indicates the presence of species of the Rochester member well down in the strata and in paleontology it may be unwise to separate the Rochester member and its fauna from the series with which it is so intimately bound in this typical section. To expand the group value of the term *Clinton* by the addition of the member Rochester involves a subtraction from the Niagaran group in like degree. This procedure may be necessary however as it is evident that final resolution of the original Clinton will leave no element that can serve as a Clinton member, except perhaps the ore beds which have long held wide recognition in the Appalachian region as the *Clinton iron ores.*

Dikes near Clintonville, Onondaga co. Dr Burnett Smith of the geological department of Syracuse University has recorded in *Science* (Nov. 19, 1909) his recent discovery of heretofore unknown igneous dikes in the sedimentary rocks of Onondaga county. Dr Smith's notice follows:

The presence of a few igneous intrusions in the almost undisturbed Paleozoic strata of central New York has long been known to geologists. Their extreme rarity, however, has always invested them with a peculiar interest.

Excluding the Manheim dike, near Little Falls, which lies about 75 miles east of Syracuse and which cuts Ordovician strata, we find that these igneous rocks may be grouped geographically into (1) those occurring in the vicinity of Ithaca and Ludlowville and (2) those occurring in the vicinity of Syracuse. In both regions the intrusions are peridotite and are mostly true dikes cutting in the first case such Upper Devonian formations as the Genesee shale and the Portage and Ithaca shales and sandstones, and in the second case cutting the Salina beds of Silurian age.

As far as the writer has been able to learn, the geologically intermediate Hamilton shale has, until now, yielded no dikes and the recent discovery of two in this formation at a locality about 12 miles southwest of Syracuse and about 40 miles northeasterly from Ithaca is believed to be a matter of interest.

The dikes in question are exposed on the south wall of the Clintonville ravine at a point approximately 50 feet above the level of the Marietta road. The more western is a fine grained porphyritic rock resembling peridotite. What appear to be serpentine grains, produced by the alteration of olivin, protrude from the weathered surface and have the appearance of small pebbles. Another conspicuous feature is furnished by large scales of a bronzy mica. This dike has a uniform width of from 7 to 8 inches and is displayed for about 12 feet on the south bank of the ravine. On the north side it is obscured by talus. Its plane is vertical, while its direction is north and south, agreeing in this latter respect with the Ithaca dikes. Wherever examined it presents a very uniform texture, is apparently free from fragments of the sedimentary rocks through which it passed, and has produced little contact metamorphism.

The second dike discovered by the writer lies about 2 feet and 4 inches to the east of the first and was not observed until the wall at this point had been cleaned. It has a width of about 8 inches. Like the first dike, it is vertical and north and south in direction. It differs, however, from the first dike in being much weathered in places and in containing many shale fragments some of which have a long diameter of 3 inches or more.

Dr Smith has, at my request, supplied specimens from these interesting occurrences for examination by Prof. C. H. Smyth jr, whose acquaintance with the other dikes on the sedimentaries of central New York is intimate, and the latter has supplied some notes thereupon, essentially as follows:

They are greatly altered alnoites. The olivin is completely broken down into serpentine, magnetite and, often, carbonates. At the same time, the mica remains surprisingly fresh, as it does in other dikes of the region. Perofskite, so abundant in the Manheim dike, is much less conspicuous here, while the critical mineral, so far as classification is concerned, melilite, is almost obliterated. One section from each dike, however, shows what I consider quite unmistakable traces of melilite, in one case a good deal of it, and I have no doubt that if the material were entirely fresh, the rock would prove to be quite typical alnoite.

At first glance, it may appear that the presence or absence of melilite is a trifling matter, since, at most, it probably would be only a minor constituent, the rock consisting chiefly of olivin and mica, and thus, for the most part, resembling, if not belonging to, the peridotites. But, really, the question is of more than ordinary interest, for as soon as melilite appears in an olivin rock

of this type, we are dealing with a rare variety, which is rarely found except in association with nepheline-syenite.

From this it follows that the presence or absence of melilite, instead of being a mere matter of one mineral more or less in the rock, determines the latter as belonging in the alkaline or subalkaline group, as the case may be, the peridotites belonging in the latter class, the alnoites in the former. Now as this distinction, recognized by Iddings nearly 20 years ago, and recently emphasized by Harker, is probably the most fundamental and far-reaching subdivision of igneous rocks that we have, it is, of course, a vital matter in the history of these dikes to determine in which group they belong, and the whole matter turns upon the one mineral — melilite. If the rocks contain melilite, they are alnoites and in the alkaline, or, to use Harker's term, Atlantic group. On the other hand, if they contain no melilite, they are peridotites and belong to the subalkaline or Pacific group. As these groups are not only of the first order of magnitude, but, as shown by Harker, may be genetically connected with major types of crustal movement, there is a heavy responsibility resting upon this one regrettably unstable mineral.

Rock cities of Cattaraugus county. It is not generally known that these singularly picturesque exhibits of rock decay are entirely unique among the scenic features of this State. New York is well supplied with striking scenic effects resulting from the more usual procedures of natural forces; cataracts and erosion gorges, ravines and chasms, mountains of grandeur and stockaded cliffs; natural rock bridges and subterranean caverns. These rock cities, however, particularly that situated a few miles south of Olean, Cattaraugus co., are phenomena of another order, wherein the decomposition of the rock beds under meteoric agencies has broken and gashed the rock beds into extraordinary picturesque effects. Their unusual features attracted the special attention of the geologists at the time of the original survey, 1836–42, and Professor Hall made an extended reference to them, accompanied by a series of effective sketches drawn by Prof. Eben N. Hosford, then his field assistant.

These rock cities are situated high on the summits of the hills and in the days of the pioneer survey were accessible only with difficulty. The growth of population and facilities of intercourse have now brought the most striking of these, that near Olean, into easy reach of the public, by means of a trolley system running thence to Bradford, Pa. over a route of rare picturesqueness. The Olean rock city is happily under control and protection from the encroachments of timber cutting and oil drilling which had begun to attack it.

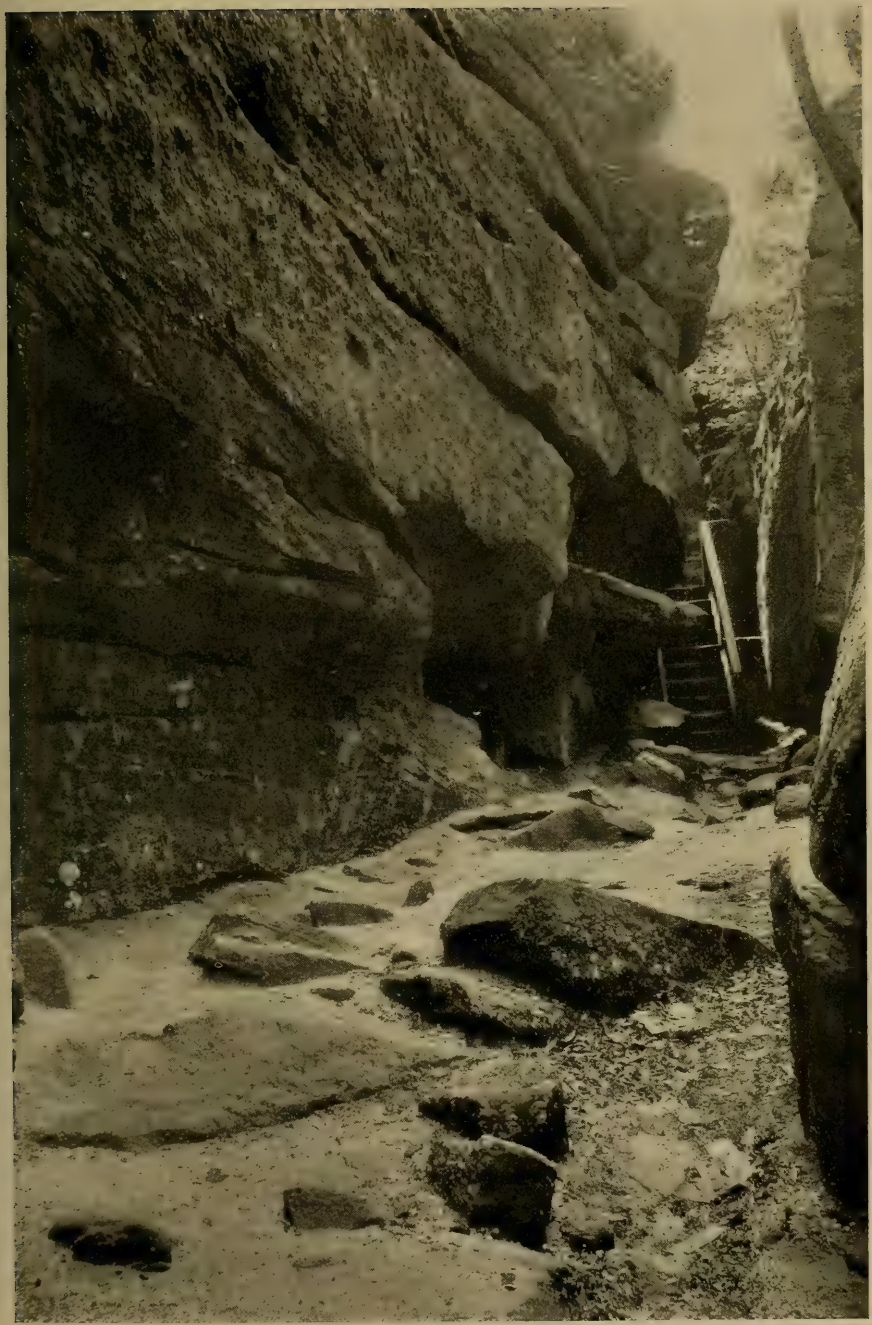
Sketch of the northern edge of the conglomerate, 6 miles south of Olean, in Allegany county. From a sketch by Prof. E. N. Horsford, published in the Geological Report of the Fourth District, 1843

Olean Rock city. Top of the conglomerate with joint crevices

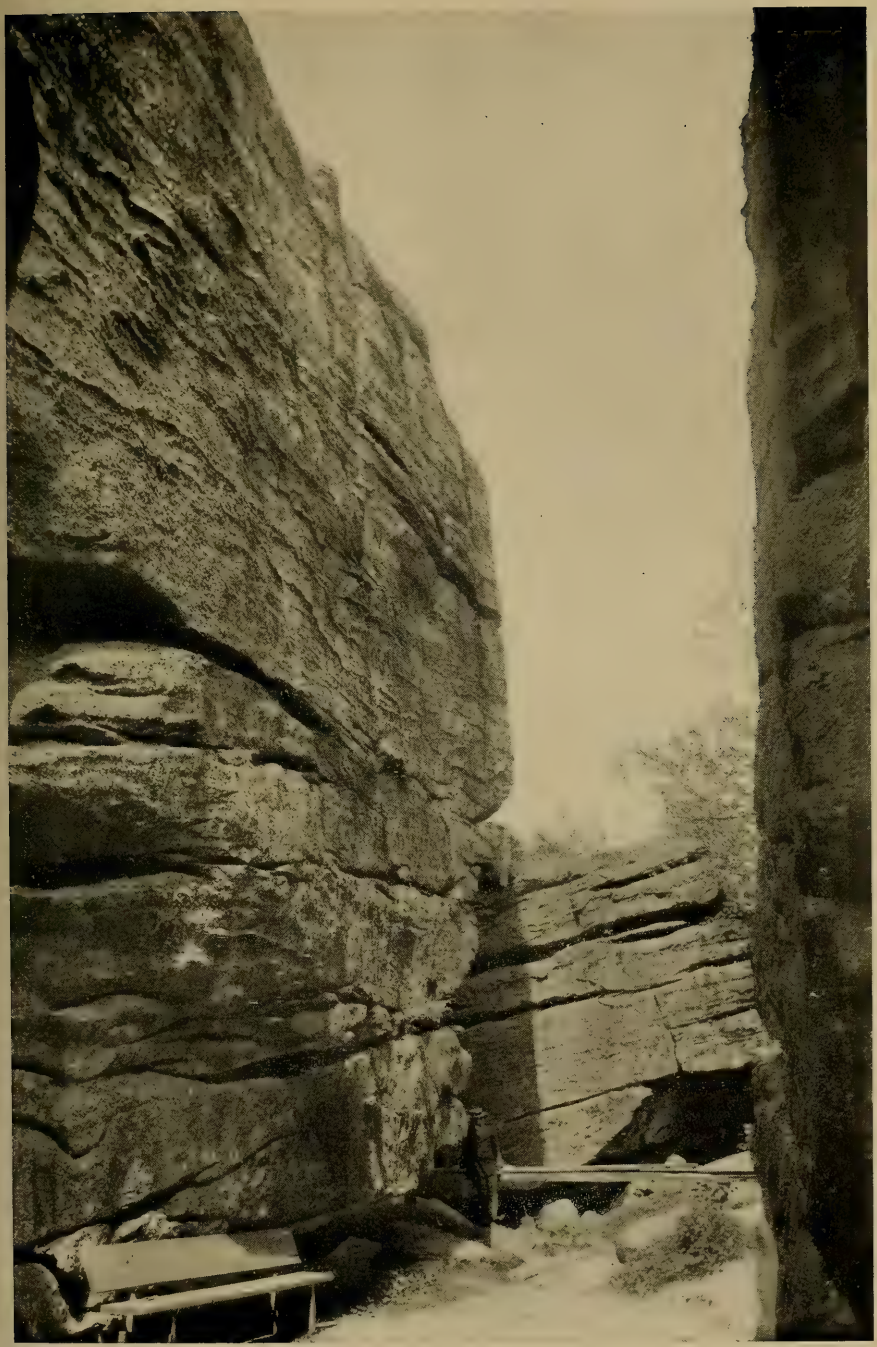
Olean Rock city. Surface of the white quartz pebble conglomerate

Olean Rock city. "The Arch"

Plate 4

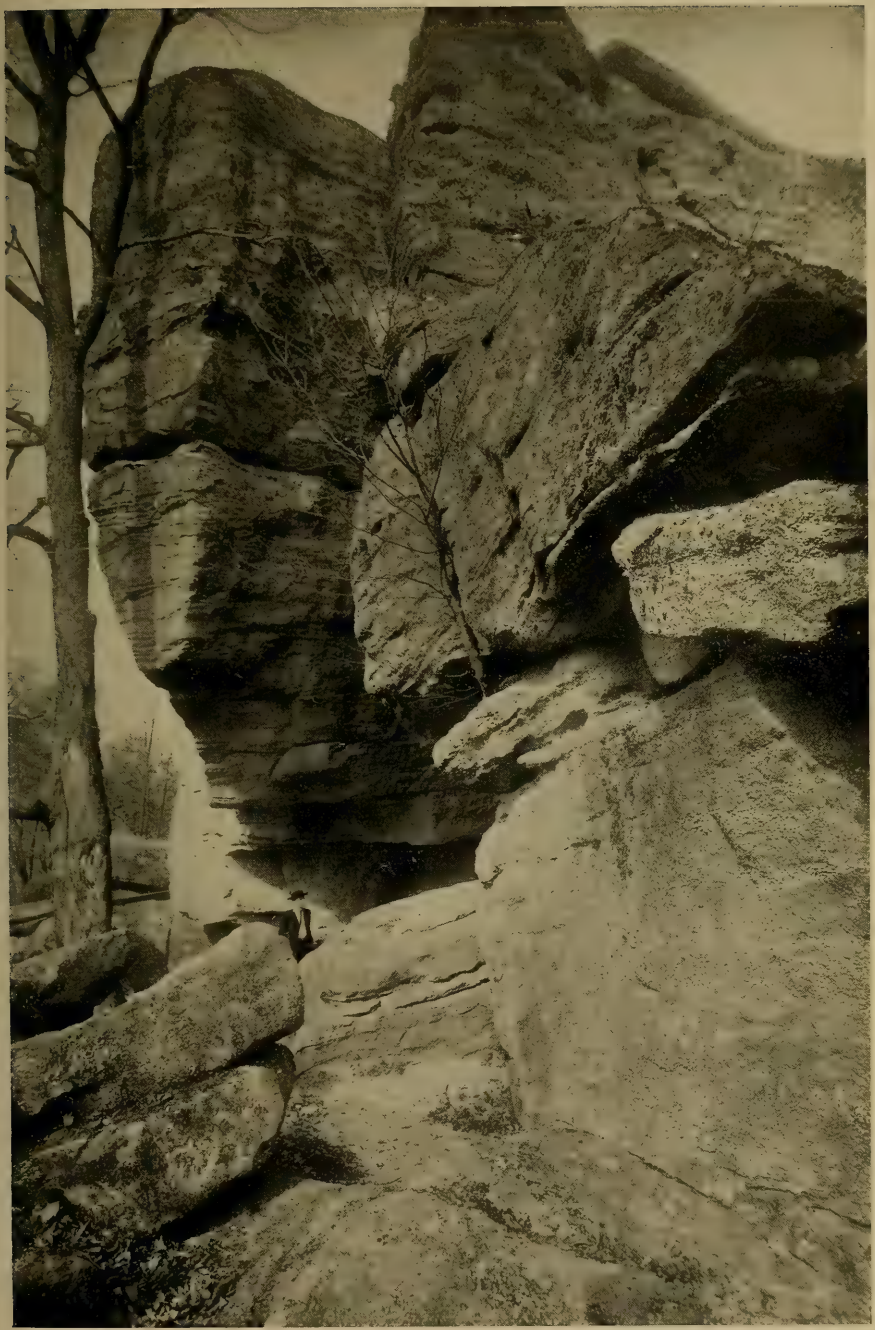


Olean Rock city. The bottom of a joint crevice due to decay



Olean Rock city. Weathered crevice in the conglomerate

Plate 6

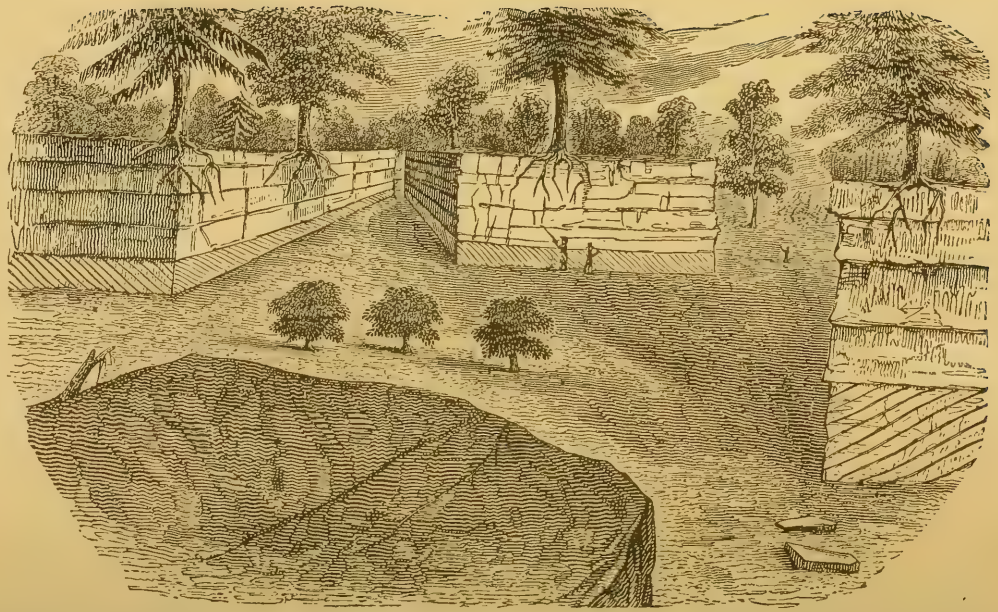


Olean Rock city. The jointed conglomerate partly undermined by decay

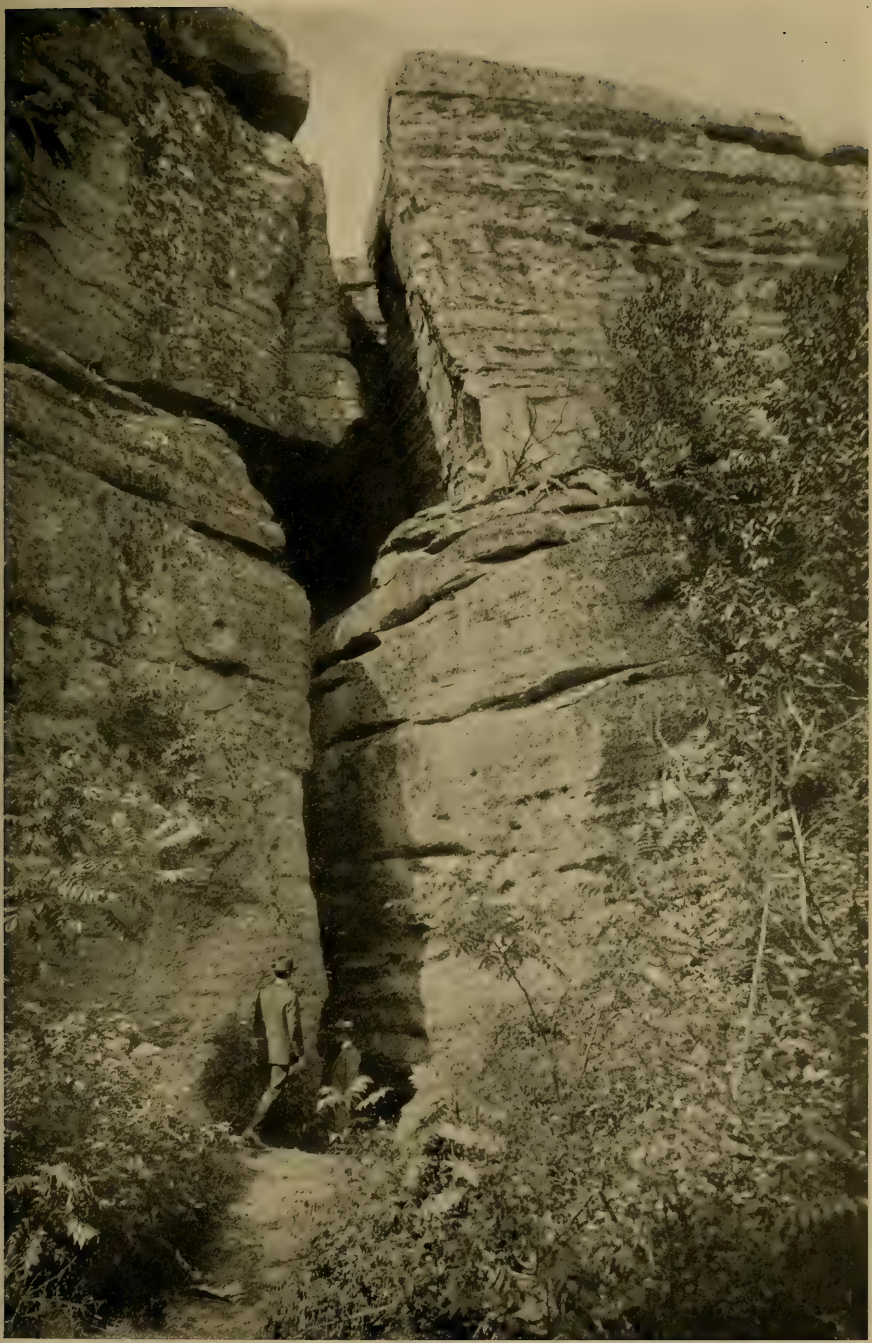
These rock cities consist of immense quadratic blocks of conglomerate (Olean conglomerate of the geological series) which form the capstone of the broken plateau whereon they rest. The Olean rock city lies at 2400 feet above tide and is highest of them all. The procedure of erosion in cutting out the bounding valleys of these hills has left only remnants of this sheet of white quartz conglomerate, now broken up into giant parallelopipeda by the slow action of atmospheric agencies working along original lines of structure. These structural lines are the vertical series of joint faces produced by shrinkage in and lateral strains upon the rock beds. The Olean conglomerate which composes the Olean rock city, is represented here in very nearly its entire thickness in this State and although for a large part a conglomerate of rounded milk-white quartz pebbles, yet the intervening bands of deposits are fine quartz sand.

There is nothing above this conglomerate except a few feet of sandy shale which are now embraced within the same geological unit. This Olean conglomerate not only forms the capstone of these southern hills, but also the capstone of the New York series of geological formations, it being the highest and latest term in the Carbonic rocks of the State, corresponding in part to the Pottsville division of the Pennsylvania coal measure series.

The easy decomposition of this rock is due to the fact of its singular weakness of cementation. The pebbles and sand grains are held together, not by any calcareous binder, but by a faint and tenuous deposit of silica derived from the solution and redeposition of the quartz pebbles themselves. So feebly are both conglomerate and sandstones bound that an easy blow, often no more than a hand pressure, will separate a fragment. It would appear therefore that time has still been wanting for a firm cementation by redeposition of a secondary silica,

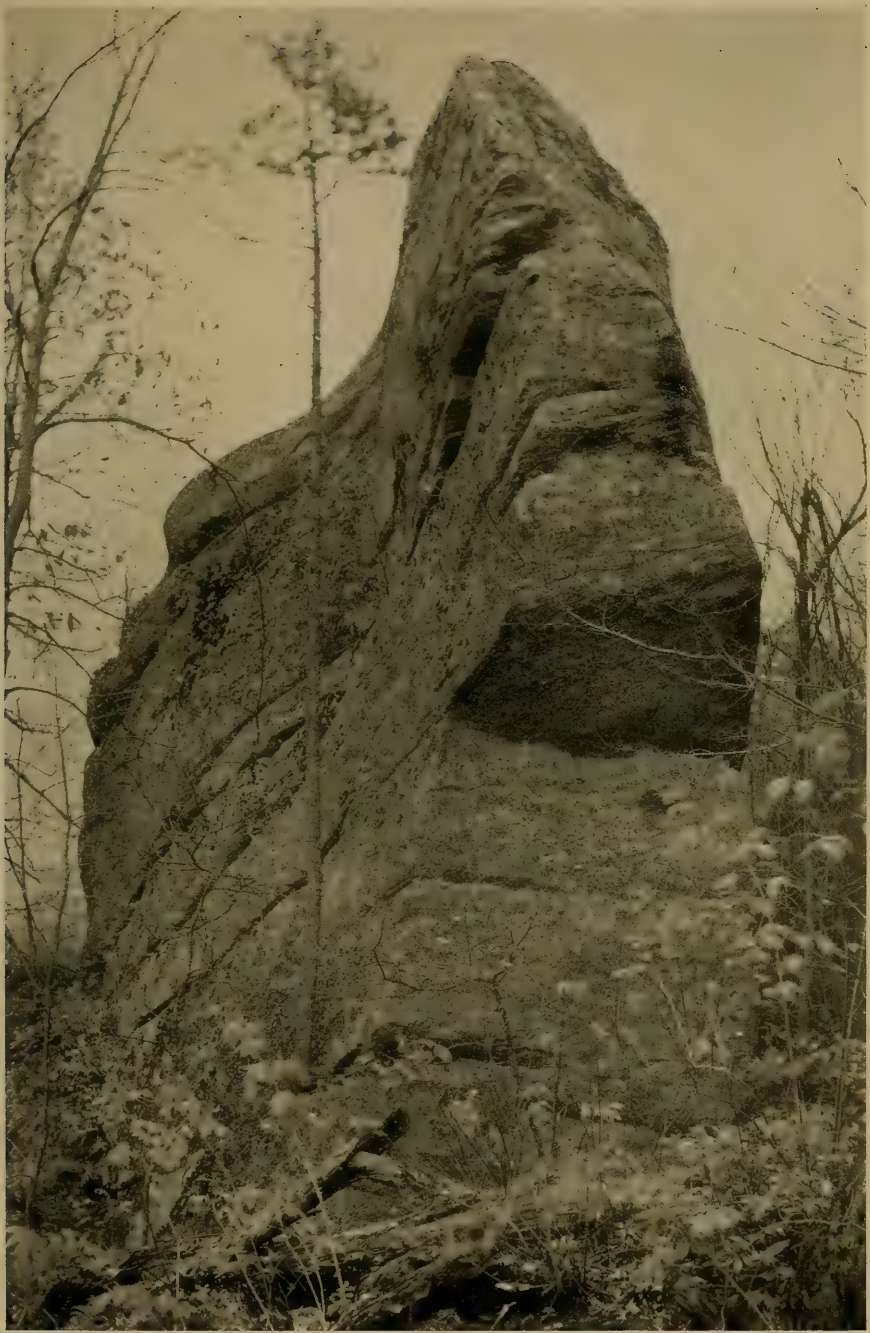


View in Rock City, 7 miles south of Ellicottville. From a sketch by Prof. E. N. Horsford, published in the Geological Report of the Fourth District, 1843



Olean Rock city. A weathered joint crevice

Plate 8

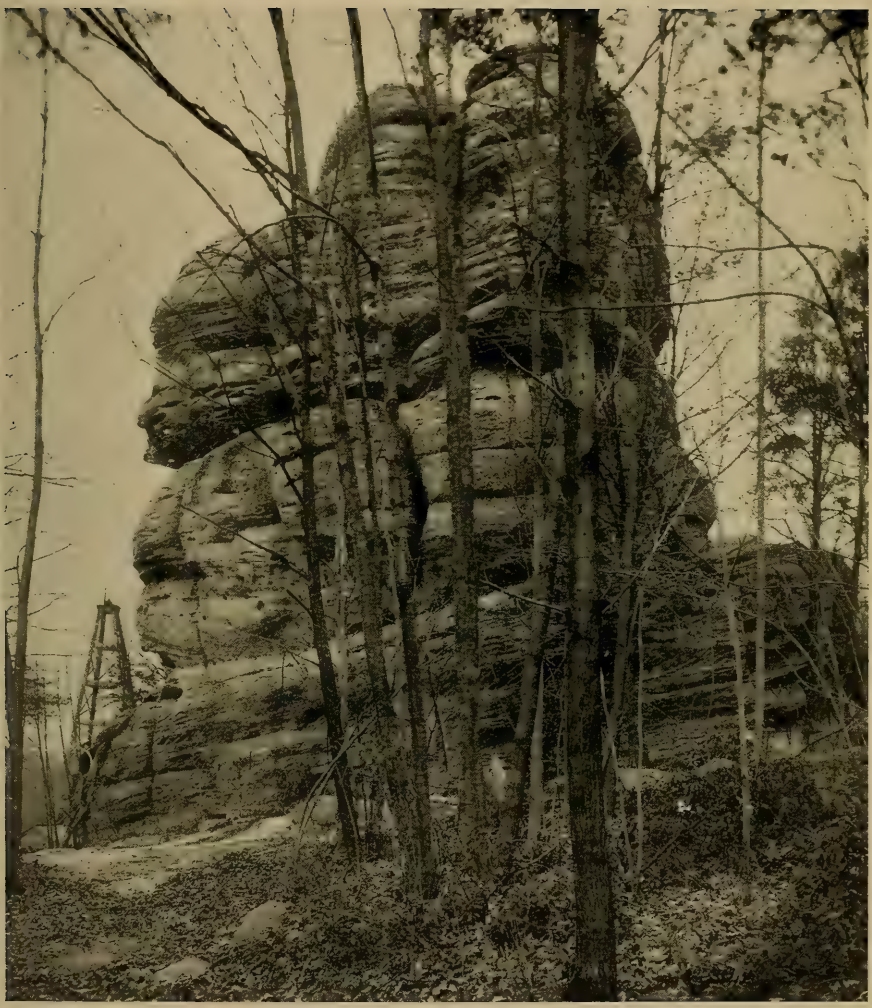


Olean Rock city. "The Swine's Snout"

Olean Rock city. Vertical and horizontal weathering

Olean Rock city. "Lone Rock," an isolated residual mass

Plate 11



Olean Rock city. "Lone Rock"

or that, the secondary silica has of itself been less resistant to atmospheric decomposition than the primary vein quartz of which the pebbles are apparently constituted. Yet it is not necessary to regard this secondary deposition as a large factor in cementation. Indeed cementation here has chiefly been effected by secondary crystal growth of the constituent pebbles. Some investigators have thought that the conglomerate pebbles displayed general evidence of etching under the action of organic acids. The eye is attracted at once by the glistening surface of these pebbles, reflecting the light from a multitude of facets, and these facets are all of crystal growth. Indeed pebbles are easily found wherein this crystal enlargement has gone forward to almost complete construction of the simple prism and pyramid with the original rounded pebble visible as a nucleus. This enlargement is general throughout the deposit and implies room between the pebbles for such growth; hence a very loosely cemented mass chiefly now held together by the locking of the secondary deposit. This general condition of weakness has been the cause of breaking down the rock beds wherever there are lines of slight resistance; thus principally along the almost rectangular series of vertical joints the dissolution here resulting in quadrate blocks standing like masses of floe ice floating on the sea.

Again easy passage through or between the strata has weakened and undermined the support of the blocks so that they have been tilted over at various angles. Thus the picturesque chasms, the sunken grassy walks, the rock bridges and the dangerous clefts are to be accounted for.

Examination of the original quartz pebbles under the crust of secondary growth shows sufficient evidence of the dynamic strains to which they were subjected in the formation of the rock masses from which they were derived, but of the geographical origin of these pebbles, what land it was that furnished them and by what lines of transportation they were brought hither are problems still remaining to be solved.

Supposed gold sands of the Adirondacks. The past year has witnessed a recrudescence of interest in the alleged gold-bearing sands of the Adirondacks. This office is frequently called upon for information on this subject, as well as for an expression of opinion regarding certain enterprises which have been inaugurated for the purpose of working such deposits on a commercial basis. The occasion seems opportune, therefore, to publish a general statement for the consideration of those who may have little

familiarity with the geology and mineral resources of that region. It is not within our province to offer personal advice to prospective investors, but it is proper to set forth the results of investigation and other matters of record that bear upon the matter.

There have been many attempts to promulgate a gold-mining industry in the region. The thoroughness with which the prospector for precious metals has covered the ground is to be seen in the abandoned pits and diggings that are scattered over every section. During the Klondike excitement, 10 or 12 years ago, the Adirondacks became the scene of a veritable rush for gold and practically every available sand heap was taken up for exploration. In the year 1898 alone there were filed nearly 4000 claims to gold and silver discoveries in the State, mainly within the Adirondacks.

The basis of all this activity is the alluvial and glacial sands which occur in almost every stream valley. These sands are not derived from remote regions to the north — though the opinion seems common that they have been transported by ice from Canada and even from as far away as Alaska — but are the result of erosive agents working upon the local rocks. They consist entirely of the minerals of the country formations which are chiefly granites, syenites, gabbros and gneissoid rocks of very ancient origin. Along with the lighter components, quartz and feldspar, there is a small proportion of the heavy minerals like garnet, pyroxene, hornblende and magnetite which have sometimes been separated by water action into distinct layers and which are found as black sands along the shores of the Adirondack lakes.

It is in these heavier concentrated portions of the sands that gold should be found if present anywhere in the region. Assays by reputable firms have occasionally shown a small quantity of gold, ranging from a mere trace to perhaps $1 a ton. The examination of innumerable samples under the microscope has failed to reveal any of the precious metals, though of course such evidence is not conclusive as to their absolute presence or absence. On the other hand the claim has often been put forth that the common quartz sands in certain places carry from $2 to $20 a ton, which, if true, would under ordinary circumstances bring them into the zone of practical exploitation.

The statement is commonly made by interested parties that the fire assay is unsuited to the determination of gold in these sands and special analytical methods must be employed. To this it can only be said that the fire assay has stood the test of long practice

in all the mining regions of the world. No reasonable explanation for its failure in the present instance has been forthcoming, though by the use of such vague terms as "volatile gold," "atomic condition" and "chemically combined gold," there seems to be an implication that the gold is driven off or left untouched by the fire. As a rule the gold found by fire assay is several per cent more than the amount extractable by the most refined commercial processes.

The exact methods for the recovery of the gold have usually been kept secret, out of the reach of scientific inquiry. They, rather than the mines themselves, seem to be the principal consideration in the organization of these ventures. From such information as has been given to the public, it would appear that they are generally based on some variation of well known methods or are a combination of processes in use elsewhere for gold recovery.

A good example of Adirondack practice, if it may be called such, is to be found in the so called Sutphen process which was in vogue about 10 years ago. Mills of ambitious design were erected at Hadley and Glens Falls for its exploitation. It involved pulverization of the sand, treatment with a secret solution, and amalgamation. The necessity for grinding the sand, already in a fine state, was alleged to be the distribution of the gold in the interior of the quartz grains. The success of the treatment, however, hinged on the character of the chemical solution, since the metal was stated to exist in combination with bromine and had to be set free before it would amalgamate. So much information was vouchsafed by the principals of the enterprise in an investigation by this Survey. A sample of sand taken from the bank from which the mill at Hadley was supplied showed by fire assay only a trace of gold, or less than 25 cents a ton, and no bromine. The enterprise received a great deal of attention during its brief career. The yield from the mill was said to have been as high as $7 a ton, and the working costs only $2.50 — a handsome margin of profit for gold mines of the present day.

It would appear as a matter of general experience that a necessary condition for the supposed widespread distribution of auriferous sands is the existence of quartz veins or other deposits of primary nature to which the sources of the gold could be traced. So far these have not been found, and in view of present knowledge of the Adirondacks, it seems very unlikely that they ever will be discovered. The quartz veins that occur in the region partake little

of the characters of those found in gold-bearing sections, being essentially destitute of iron sulfids and other minerals with which the precious metals are most generally associated. That they contain traces of gold is likely, but they do not afford any adequate basis for mining enterprise (except as possible sources of quartz) or for the accumulation of secondary deposits like placer sands and gravels.

There is little need for going further into details in this matter, though it may be said briefly that the Adirondacks form an independent geological and mineral province, only remotely related to the other mountain ranges of the eastern United States. The fact of the existence of gold deposits along the Appalachians from Nova Scotia to Alabama can scarcely be quoted, therefore, as an argument for the presence of analogous deposits in the Adirondack region.

While deficient in the precious metals, the region possesses the elements of large mineral wealth. Its production of iron ores, talc, garnet, graphite, pyrite and building and monumental stones of various character is a very important contribution to the mineral output of the country. There is abundant opportunity for future development of such resources and it is in that direction rather than in the seeking of the precious metals that energy and capital can be best employed.

The fact that the profits of mining are not to be gaged by the relative value of the mineral produced is a commonplace. If a balance could be struck, it would show probably that the homely iron ores better reward industry than all the gold and silver wherever found.

Industrial geology

Gypsum resources. With the growth of interest in gypsum and its products that has taken place in recent years, there has developed a need for a more thorough consideration of the New York deposits, commensurate with their commercial importance. Previous studies have afforded scarcely more than an outline of their field distribution and insufficient information of their character and utility, as in fact for a long time they were considered of small value except for local agricultural requirements. The discovery that the gypsum can be employed in the manufacture of calcined plasters has led, in the last decade, to the establishment of numerous enterprises, and there is every promise of a continued expansion in the industry for years to come.

Recent field investigations have extended from Madison county

west to Erie. The gypsum deposits are found in the upper part of the Salina formation which outcrops as far east as Albany county, but they attain workable dimensions only in the central and western areas where the Salina beds are thickest. Within this section which measures over 150 miles east and west they show a wide range of character, as one might expect; while there is also considerable variation in the size and sequence of the bodies.

Chemical analysis of various selected rock samples indicates that a relation more or less consistent exists between the composition and geographic distribution of the gypsum. In general it may be said that there is a progressive increase in the percentages of gypsum substance and a corresponding improvement in physical qualities as the deposits are traced to the west. This relation may be the expression of original conditions surrounding their accumulation which will later be considered. In the eastern counties the gypsum is admixed with clay, lime and magnesian carbonates and silica, the proportion of these impurities ranging up to 25 per cent or more of the whole mass. On the other hand the deposits in the western part of the belt show as little as 5 per cent of foreign ingredients and are much lighter in color.

The valuable bodies occur interbedded in the Upper Salina shales. They occupy usually large areas, as compared with their vertical dimensions, or in other words are stratiform. There are, of course, variations and irregularities to be found, but the stratiform type is the predominant and original one; the extreme departures from that type such as have been described and figured in the reports of James Hall and in Dana's *Manual* are in most instances to be regarded as modifications brought about by the solvent effects of ground waters. Besides the larger beds small seams of crystallized transparent gypsum, which appear to be secondary depositions, occur through the shales, so abundantly distributed in some places that the mixed shale and gypsum has been worked during times past to supply local needs for land plaster.

The forthcoming report will include a consideration of the origin of the gypsum, a subject that has economic bearings as well as geologic interest. Without entering into details of evidence here, it may be said that the gypsum is considered an accumulation from sea water evaporation contemporaneous in

general with the deposition of the accompanying shales and limestones. The rock salt which occurs lower down in the Salina is a product of similar conditions. Owing to the seemingly abnormal position of the main gypsum beds with respect to the salt and to the occurrence of irregular discontinuous masses near the surface, the view has sometimes been taken that the deposits represent former limestones which after their uplift were altered to gypsum by underground circulations carrying sulfuric acid. If this explanation were true the resources might prove to be limited, since their existence would be dependent upon purely local conditions. It is to be doubted, however, if such methods of origin can be applied to the valuable beds of rock gypsum.

Up to the present time the deposits have been attacked only at the more advantageous places on or near the outcrop. In the eastern section where they are thickest open-cut operations are the rule, while in Monroe county and farther west, they are commonly worked underground either from an adit driven from the face of a hill or by means of a vertical shaft. There has been little systematic exploration, but the need of it will come with the progress of the industry, particularly in the western counties which are the centers of plaster manufacture. The report will contain maps and other matter to indicate the more promising fields for future development.

Review of mines and quarries. The canvass of the mining and quarrying enterprises of the State, relative to the year 1908, showed that conditions were less prosperous than in the few years immediately preceding which were reviewed in former reports. The total value of the mineral production, itemized under 34 materials, was $29,519,785. The corresponding figures for the year 1907 were $37,141,006, so that the decrease amounted to about 20 per cent. The lessened activity was not, however, attributable to factors of local import, but to the wide-reaching depression that affected all lines of business. An improvement will doubtless be shown by the statistics for the current year, though the industry can hardly be expected to regain fully its former activity in so short a time. The iron mines perhaps suffered most from the financial stress owing to the fact that many of the properties were still in the developmental stage and without the resources of established enterprises.

The collection of the mineral statistics for the year was accom-

plished with the cooperation of the United States Geological Survey, under the agreement published in my last report, the two offices sharing the work and the use of the results.

Iron ore explorations. The Lake Sanford region, Essex co., was visited for the purpose of recording the recent developments that have taken place since the issue of the report on the Adirondack magnetites. Exploration with the diamond drill has demonstrated the presence of many millions of tons of ore, thus confirming the general opinion relative to the resources of the region. Experiments in the reduction of the ores are still under way and their favorable outcome will mean a very large increment to the mining industry of the Adirondacks.

Examinations have also been made of the Forest of Dean mine near Fort Montgomery and of the arsenical pyrites mined near Carmel, Putnam co.

SEISMOLOGICAL STATION

The seismographs in the basement of the State Museum have continued to render efficient service, with only occasional stoppages of short duration for the purpose of slight repairs or readjustments. Since their installation in March 1906 they have registered 54 different disturbances. The number registered during the year ending September 30, 1909, was 19 as compared with 9 in the preceding year. The seismic frequency has thus been rather notable, equalling in fact the record for the year 1907–8 which was distinguished by a series of very heavy earthquakes in Mexico, the West Indies and Central Asia, that involved many minor readjustments in their train.

The sources of the shocks in the past year have been fairly well distributed over the different seismic zones. The Cordilleran region, after the repeated rackings that followed the San Francisco earthquake and extended from Alaska to Chile, seems now to have settled down to a more normal condition. Slight tremors only have been reported from that region. The loci of pronounced activity have shifted to the east-west zone which extends from the Mediterranean coast to Central Asia where there have been several heavy earthquakes; of the number the Messina earthquake of December 28, 1908, involved the most appalling catastrophe that has ever been inflicted upon a civilized country. The shock itself does not appear to have been commensurate with the enormity of the destruction, the tracing obtained at Albany as well as at other stations showing

no remarkable features. Within the same zone belong the disturbances of India, Persia and western Europe of which records are included in the accompanying table.

As usual the local station has freely communicated its observations to those engaged in seismological investigation and to the press. Facsimile reproductions of the San Francisco records are included in the final report of the California Earthquake Commission recently published by the Carnegie Institute. It is hoped that a systematic exchange of records may be inaugurated between the several stations in the eastern United States and Canada; the comparison and coordination of data from a number of observational centers would be highly desirable.

In reference to the accompanying records it may be stated that the Albany station is equipped with two Bosch-Omori horizontal pendulums. One of these is set in the meridian and the other at right angles. The weight of each pendulum, including arm, is 11.283 kilograms and the distance of center of gravity from rotating axis is 84.6 centimeters. Their period is maintained at about 30 seconds; their multiplying ratio is 10. They have no artificial damping device. Albany is situated in latitude N. 42° 39′ 6″, longitude W. 73° 45′ 18″. The base of the instruments is 21 meters above sea level.

RECORD OF EARTHQUAKES AT ALBANY STATION, OCTOBER 1, 1908 TO OCTOBER 1, 1909

Standard time

DATE	Beginning preliminaries	Beginning principal part	Maximum	End	Max. amplitude
1908	h. m.	h. m.	h. m.	h. m.	mm.
October 13	12 18 a. m.	12 26 a. m.	12 32 a. m.	1 07 a. m.	2
November 6	2 50 a. m.	.....	.....	3 13 a. m.	.....
November 30	4 50½ p. m.	4 57½ p. m.	4 58 p. m.	5 33 p. m.	2
December 27–28	11 40 p. m.	.....	12 00 noon	12 19 a. m.	4
1909					
January 22	10 31½ p. m.	10 47 p. m.	10 47½ p. m.	10 56 p. m.	2
February 16	11 56 a. m.	.....	.....	12 13 a. m.	.....
February 26	12 00 noon	12 05 p. m.	12 05 p. m.	12 30 p. m.	1½
April 10	2 06 p. m.	2 18 p. m.	2 19 p. m.	2 30 p. m.	1½
April 24	8 29 p. m.	.....	.....	2 38 p. m.	.....
May 17	3 19 a. m.	3 21 a. m.	3 21 a. m.	3 48 a. m.	5
May 18	12 03 p. m.	.....	.....	12 23 p. m.	.....
June 8	1 09 a. m.	.....	.....	1 40 a. m.	.....
July 7	4 54 p. m.	5 01 p. m.	5 05 p. m.	5 45 p. m.	2
July 30	5 58 a. m.	6 12 a. m.	6 16 a. m.	7 09 a. m.	24
July 31	2 31 p. m.	2 41 p. m.	2 43 p. m.	3 20 p. m.	6
August 16	2 05 a. m.	2 15 a. m.	2 18 a. m.	2 44 a. m.	20
August 31	7 06 a. m.	.....	7 16 a. m.	7 41 a. m.	.....
September 8	12 00 noon	.....	.....	1 09 p. m.	.....
September 22	9 54½ a. m.	10 02 a. m.	10 03 a. m.	11 30 a. m.	2

October 13. The vibrations continued for nearly an hour and their east-west component was the stronger. They appear to have been set up by a distant shock, perhaps originating in central Europe, which was in a state of unrest at about that time.

November 6. Very small vibrations of which only an east-west component was recorded. Severe earthquakes were felt in Italy, central Europe and southwestern Asia at corresponding times. They were probably preliminary to the Messina disturbance of December 28th.

November 30. Well marked though small vibrations of about equal magnitude on both instruments. Origin unknown.

December 27–28. A record of the disastrous earthquake at Messina, Italy. The vibrations at this station lasted about 40 minutes and reached a maximum amplitude of 2 millimeters at 12 midnight. Only very faint movements were shown by the east-west pendulum. Other stations in this country and in Europe reported the wave motion to have been of moderate dimensions. The earthquake was due probably to crustal dislocation along the depression occupied by the straits of Messina.

January 22. Record of devastating earthquake in the province of Luristan, Persia, in which 60 villages were wholly or partially destroyed. The shock was of world-wide compass and was reported by almost all stations. No direct news of its effects in Persia was received till February 17. The vibrations at this station were of about the same intensity as those set up by the Messina earthquake, though they traveled a much greater distance. No vibrations were indicated on the pendulum recording the north-south component.

February 16. The shock traveled apparently in an east-west direction. The movements lasted for 17 minutes with oscillations of small amplitude. They may be referred to the violent shock that was felt throughout Alaska on the same day and reported from Skagway Lynn canal at 7.30 a.m.

February 26. Record more clearly indicated on the east-west instrument. The epicenter is estimated at 2500 miles distant. The shock was also recorded by the Ottawa station.

April 10. Record obtained only on the north-south instrument. The shock was of moderate intensity, with a maximum amplitude of 1½ millimeters. Its origin is unknown but appears to have been about 6000 miles distant, possibly in the eastern Mediterranean region.

April 24. Slight oscillations of unknown origin recorded by both pendulums.

May 17. Vibrations of moderate intensity; recorded also at Washington and Toronto. The origin is uncertain but has been assigned to Chile where earthquakes were felt at this time.

May 18. A series of vibrations of moderate intensity traveling in an east-west direction. Their origin is unknown.

June 8. Record of a slight earthquake which occurred in Copiapo, Chile.

July 7. The disturbance can be traced to the shock reported from various parts of India. The vibrations began at 4.54 p.m., which, with due allowance for difference in longitude and time of transmission, would correspond to about 3 a.m. at Bombay or between 3 and 4 o'clock a.m. in central India. The movements were of small amplitude and continued for about an hour. As India is on the opposite side of the globe, the movements were probably transmitted across the polar regions as well as in an east-west direction. Stations in Russia, Germany, Spain and Canada also reported the same earthquake.

July 30. A record showing vibrations of unusual intensity with a maximum amplitude of 24 millimeters. Both pendulums were affected equally and owing to the similarity of this record to other Mexican ones and to the calculated epicentral distance, it is believed that the epicenter was in Mexico or South America. The shock was also recorded at Ottawa and its epicenter placed in Mexico.

July 31. Vibrations very similar to those of July 30, but of much less amplitude. This record probably represents the earthquake felt in Mexico City.

August 16. The record of a small earthquake reported near Mexico City. The record which is unusually distinct and regular, shows an amplitude of 20 millimeters and a duration of movement of about 40 minutes. Records were also obtained at the Ottawa, Baltimore and Washington stations.

August 31. Very small vibrations recorded on both pendulums. Possibly represents the vibrations from a slight earthquake reported in Rome, Italy.

September 8. A small movement indicated on the seismographs at this station, Ottawa and at Washington. The origin was calculated to have been 4000 miles distant.

September 22. A vibration of moderate intensity and con-

tinuing for about 2 hours. This origin can possibly be assigned to southern Europe since earthquakes were reported from France and Italy on this date.

MINERALOGY

In the section of mineralogy the work of investigation for the past year has included the completion of the memoir on the crystal forms of New York calcite, now in press, and several short papers on New York occurrences as well as two short crystallographic notes on the calcite from the New Jersey trap region, closely extralimital.

The rapid advances of crystallographic knowledge in recent years, resulting in the publication of a very considerable number of papers in all languages, has created the necessity for a systematic arrangement of the new forms added to all the important mineral species since the publication of Goldschmidt's *Index der Krystallformen der Mineralien* in 1891. So essential to the work of crystallographic investigation has this tabulated knowledge become that a card catalogue of the new crystal forms recorded since 1891 has been undertaken. This catalogue which has been completed through the letter I, indexes up to that point 1107 new forms. The catalogue records the letter, symbol, author, publication and date and has been compiled from all available sources.

The work of cleaning and preparing for exhibition the large suite of calcite from Sterlingbush, Lewis co., has been undertaken and is now well in progress. The exceptional quality of this material, when freed from the incrusting layer of stalactitic carbonate of lime, fully justifies the high estimate of its beauty and value formed from its appearance in the rough. Most of the large crystals show beautiful coloring and interesting multiple twinning. It is hoped that the many duplicate specimens of this enormous and valuable series will prove to be highly profitable exchange material.

Many valuable specimens have been acquired during the past year by purchase and exchange, including a fine specimen of the new species natrochalcite and representative specimens of the rare minerals cabrerite, kröhnkite and newberryite. A fine series of trap minerals from the new Erie Railroad cut at Bergen Hill, N. J., has been added to the already representative collection from that region. This latter series which includes beautifully crystallized specimens of apophyllite, analcite, natrolite, datolite, stilbite and calcite, has furnished material for investigation under the last

named species.[1] A collection rich in minerals from the Sterling iron mine at Antwerp, Jefferson co., has been acquired by purchase from R. S. Hodge of Antwerp. This contains many fine specimens of millerite from this locality, an occurrence now fast becoming rare by reason of the closing of the mine; as well as a highly representative series of crystallized hematite, dolomite, ankerite, quartz and calcite. A series of pseudomorphs of serpentine after garnet was collected from a locality about 2 miles north of Saratoga.

PALEONTOLOGY

Monograph of the Eurypterida. In my report of last year reference was made to this undertaking, which was inaugurated because of the amazing profusion of these extinct creatures in the rocks of this State. No other part of the world has afforded such variety and abundance of these ancient arachnids and our large collections have supplied much exact and unrecorded knowledge of their morphology and bionomy. Some time has been spent in the acquisition of additional supplies of material desired before bringing the monograph to its conclusion and about one thousand pounds of specimens were taken from the localities in Herkimer county.

The localities which have afforded the extensive suites of these fossils are, under present conditions, not accessible and some of them do not promise much for the future.

1 The celebrated development of the fauna in the Bertie waterlimes on the property of the Buffalo Cement Company, seems to be now approaching exhaustion. The eurypterids here have occurred in great numbers and splendid preservation, constituting some of the most striking fossil remains in the rocks of the State. Specimens from these quarries became scattered through the museums of the world, but fortunately before they were too freely dispersed the owners of the quarries determined to keep future discoveries of the kind together in the museum of the Buffalo Society of Natural Sciences, where today the Bennett Collection affords the most extensive series of these fossils from that locality. This occurrence in the waterlimes of Erie county seems to have represented a shore pool where the mature animals resorted for feeding or burrowing, but that it was not a breeding ground is suggested by the general absence of immature remains.

[1] Whitlock, H. P. Calcite from Jersey City, N. J. Fifth Report Director of Science Division, p. 219.

2 The black Pittsford shale of the same Salina formation which was exposed only by operations in widening the Erie canal, has no known surface outcrop. All the remarkable specimens recovered here were taken when the rock was fresh and there is little hope of adding to this material until the formation is again opened by civic improvements.

3 The historic localities of eurypterids in Herkimer county, in the region from Sauquoit to Wheelock's hill, have been so carefully searched that even the stone walls of the region have been quite fully overhauled. There are no known outcrops of the waterlimes in this region that now promise very much additional material or knowledge. Last year an old barn was found near Crane's Corners, whose foundation wall was largely composed of thin waterlime Eurypterus slabs taken from an outcrop no longer accessible. This foundation we removed without disturbing the building, replacing it with concrete as the removal progressed and it seems probable that the large material thus acquired is the last extensive series of these fossils to be hoped for from this region for some years to come.

4 The black shales in the Shawangunk grits at Otisville, Orange co., from which the very remarkable and extensive series of development stages were derived a few years ago, are now no longer exposed. These were shown mostly in a quarry where the sandstone was being torn out for construction of a branch of the Erie Railroad. That work is now finished and the sandstone wall stands sheer and steep with the thin Eurypterus shale beds tight in between its layers.

Aside from these four occurrences, specially noteworthy because of the abundance of their specimens, there are occasional examples to be found along the line of Salina outcrops in western New York, as at Union Springs, but these are rare and usually individual occurrences.

The monograph on these fossils is now brought to completion and early publication is hoped for.

Herein, in the chapter on morphology, a restoration of the muscular system is attempted and evidence brought forward in support of the view that the scales of the integument are muscle scars; the structure of the compound eye of Pterygotus is recognized as consisting of an outer smooth cornea with an inner system of papillary prolongations of the cornea serving as lenses, and thereby the homology of the eye of Pterygotus with that of

Limulus is demonstrated; it is shown that the chelicerae of Pterygotus consist of but three joints as those of the other eurypterids, the long proximal joint being undivided.

The probable mode of life of these strange creatures has been subjected to a thorough discussion and the conclusion reached that their life habits were not always uniform; on this basis they can be divided into four groups, as evinced by the form of their bodies and appendages; these groups being typically represented by Pterygotus, Eusarcus, Eurypterus and Stylonurus. In the first, forms of principally the swimming habit prevailed; the second were mud-grovelers and crawlers; the third are slightly specialized forms that were crawlers, burrowers and swimmers; the fourth were crawlers.

From the character of the rocks in which the Eurypterida occur and from the associate faunas, it is inferred that the eurypterids were originally marine animals, but at the time of their climacteric development in the Upper Siluric had become inhabitants of the lagoons and estuaries and were typically euryhaline, i. e. able to live in both salt and brackish water, and that this habit which they held throughout the Devonic, led them finally into the evident fresh-water habit of the expiring species in the coal lagoons of the Carbonic and Permic.

The collection of larval stages (some but 1 millimeter long) of the genera Eurypterus, Eusarcus, Stylonurus, Hughmilleria and Pterygotus has furnished data on the ontogeny of these genera which allow the following general inferences: (1) that the carapace is relatively larger in the larval stages, (2) that the compound and lateral eyes are relatively much larger than in the mature stage; (3) that they are nearer the margin; (4) the ocellar mound is large and more prominent; (5) the swimming feet are larger; (6) the abdomen lacks the distinct differentiation into pre- and postabdomen; (7) the number of segments is less; and (8) the telson spine appears to have been less developed.

Of these characters the relatively larger size of the carapace, compound eyes and swimming feet, and the smaller number of the abdominal segments are considered as cenogenetic or purely larval characters, while the approximation of the compound eyes to the margin, the prominence of the ocelli and their tumescences, the lack of differentiation of the abdomen and the smaller size of the telson, are held to be palingenetic and of phylogenetic

significance. In these palingenetic characters the nepionic stage resembles the Cambric eurypterid Strabops (Strabops stage).

The relationship to Limulus is indicated by a number of larval characters common to both the eurypterids and Limulus.

The prototype of the eurypterids has been reconstructed from the palingenetic characters of the nepionic specimens and the Cambric Strabops. By comparison of the later genera with this prototype the conclusion is reached that two separate families have been developed, the Eurypteridae and the Pterygotidae. In the latter family the genus Hughmilleria evinces the most primitive structure and Pterygotus and Slimonia have developed in different directions. The main stem of the stock in the family Eurypteridae is found by the genus Eurypterus which appears as the earliest in the Clinton and persists into the Permic. From it branch off Eusarcus and the subgenus Onychopterus which points the way to Dolichopterus, Drepanopterus and through the latter to Stylonurus.

The observations of the larval stages have been used in the investigation of the taxonomic relations of the Eurypterida. It has been found that the larval stages of the eurypterids and Limulus have all important characters in common, and that the differential characters are due to purely adaptive changes or are cenogenetic. While thus the close relationship of the two is also supported by ontogenetic facts, evidence is brought forward for the conclusion of a Precambric separation of the Xiphosurans and eurypterids. The larval stages of the eurypterids are further compared with those of the scorpions and evidence of relationship found through descent from a common ancestor. A comparison of the larvae of all three, the eurypterids, Limulus and the scorpion, has shown that both the latter have lost the primitive form of the abdomen by acceleration in which the eurypterids have best preserved the original gradual and uniform contraction, and that all three are derivable from a common ancestor to which the eurypterids are still nearest in their general aspect. It is further inferred that this common ancestor is more primitive than the crustaceans and may have to be sought among the annelids.

Monograph of the Devonic Crinoidea. Opportunity for the prosecution of this undertaking is limited to the few weeks each year that can be controlled by Mr Kirk who has been carrying on the study for several years under the conditions indicated. The

work as a whole is well advanced and as it covers a field of essentially new knowledge in this State, may constitute a substantial contribution to paleontologic science. During the past two seasons quite extensive discoveries of crinoids have been made by Mr Luther in the Chemung shale of the town of Italy, Yates co., all of which prove to be new and noteworthy additions to the crinoid fauna of the rocks. The progress made in these studies is indicated by the statement of the families represented and the species recognized.

INADUNATA

Family CYATHOCRINIDAE

Arachnocrinus bulbosus *Hall.* Onondaga limestone
A. *sp. nov.* Onondaga limestone
A. *sp. nov.* Onondaga limestone

Family DENDROCRINIDAE

Cosmocrinus ornatissimus (*Hall*). Portage fauna
Maragnicrinus portlandicus (*Whitfield*). Portage fauna

Family PISOCRINIDAE (?)

Hypsocrinus fieldi *Springer & Slocum.* Hamilton shale

Family CALCEOCRINIDAE

Halysiocrinus secundus (*Hall*). Onondaga limestone

ADUNATA

Family PLATYCRINIDAE

Cordylocrinus plumosus (*Hall*). Coeymans limestone
C. plumosus *var.* parvus (*Hall*). Coeymans limestone
C. plumosus *var.* ramulosus (*Hall*). Coeymans limestone
Platycrinus eriensis *Hall.* Hamilton shale

Family MARSIPOCRINIDAE

Marsipocrinus tentaculatus (*Hall*). Coeymans limestone

Family HEXACRINIDAE

Hystricrinus eboraceus (*Hall*). Hamilton shales
H. *sp. nov.* Chemung fauna
H. *sp. nov.* Portage fauna

CAMERATA

Family RHODOCRINIDAE

Acanthocrinus spinosus (*Hall*). Hamilton shale
Rhodocrinus nodulosus (*Hall*). Hamilton shale
Thylacocrinus gracilis (*Hall*). Hamilton shale

Family DIMEROCRINIDAE

Thysanocrinus arborescens *Talbot.* Coeymans limestone
T. *sp. nov.* Hamilton shale

Family MELOCRINIDAE

Mariacrinus nobilissimus *Hall.* Coeymans limestone
M. pachydactylus *Hall.* Coeymans limestone
M. paucidactylus *Hall.* Coeymans limestone
Melocrinus breviradiatus *Hall.* Hamilton (?)
M. clarkei *Williams.* Genesee-Portage faunas

Family DOLATOCRINIDAE

Dolatocrinus glyptus (*Hall*). Hamilton shale
D. lamellosus (*Hall*). Onondaga limestone
D. liratus (*Hall*). Hamilton shale
D. speciosus (*Hall*). Onondaga limestone
D. *sp. nov.* Hamilton shale
D. *sp. nov.* Hamilton shale
Gen. nov.
troosti (*Hall*). Hamilton shale
Gen. nov.
sp. nov. Onondaga
sp. nov. New Scotland

Family BATOCRINIDAE

Coelocrinus cauliculus (*Hall*). Hamilton shale
C. praecursus (*Hall*). Hamilton shale
C. *sp. nov.* Hamilton shale
C. *sp. nov.* Hamilton shale
Gennaeocrinus carinatus *Wood.* Hamilton shale
G. eucharis (*Hall*). Hamilton shale
G. nyssa (*Hall*). Hamilton shale
G. *sp. nov.* Hamilton shale
Megistocrinus depressus *Hall.* Hamilton shale
M. ontario *Hall.* Hamilton shale
Gen. nov.
sp. nov. Hamilton shale
Gen. nov.
sp. nov. Hamilton shale

Postglacial mammalian remains

Mastodons. In my report for 1903, a summary was given of the recorded discoveries of the mastodon in this State since the first finding of such relics in 1705, and it was accompanied by a map indicating their geographical distribution. The list there given afforded evidence of about 60 distinct occurrences.

In my report for 1906 the record was supplemented by 4 items, and in 1907 by 2 more. In order to keep this record as complete

as practicable there are now added the following items which have either escaped notice or are more recent discoveries.

1884 Perry, Wyoming co. The Museum of the Wyoming Pioneer and Historical Association at the Silver Lake Assembly, contains two teeth found on the farm of William Olin, town of Perry, in the year indicated.

1908 Kill Buck, Cattaraugus co. A single tusk has been reported as found at this date near the banks of the Great Valley creek. Details are wanting.

1908 Batavia, Genesee co. Discovery of a part of a skeleton on Willow street in this village has been reported. The bones found consisted of a few ribs, vertebrae and leg bones and it is stated that a jaw bearing teeth was also uncovered.

1908 Manchester, Ontario co. A tooth on the property of Leonard S. Lyke.

Bison. Some teeth obtained in the postglacial clays of the Hudson valley a few miles below Albany, in deposits commonly regarded as laid down during that stage of the Mohawk drainage of the Great Lakes, termed Lake Albany, have been identified by Dr O. P. Hay as those of the bison. Although entirely exact data concerning the date and location of this discovery are wanting, these teeth have come into the museum within the writer's recollection and have been kept in association with a series of other mammal relics from this vicinity. The occurrence is of interest and the only instance we can now refer to of the presence of the buffalo in eastern New York during this epoch of postglacial waters.

Moose. The Barge canal prism northwest of Waterford, Saratoga co., passes along side the site of a buried Mohawk channel. In the course of construction of foundations for guide piers between the proposed locks a number of deep potholes have been encountered, similar in date and origin to, and only a mile and a half away from, those on the Mohawk at Cohoes, in one of which the Cohoes mastodon, now in the museum, was found in 1866. The largest pothole encountered at Waterford measured 16′ by 20′ in diameter and was excavated to a depth of 14′; no attempt was made to reach the bottom of the hole. The rock surface at the top of the potholes lay buried under 10′ of laminated clays (Lake Albany clay). At 14′ vertebrae and ribs were found which have been identified by Dr F. A. Lucas as those of the *moose*. With them in the clays, were shells of the genus Planorbis, moss (Sphagnum), wood and cones. The cones have been

examined by the State Botanist who identifies them as the white spruce (Picea canadensis) and states that the nearest point known to him where this tree now grows is Olmsteadville, Essex co. This is very interesting evidence of the change in life and climate which has passed since the moose wandered through forests of white spruce in the vicinity of Waterford.

III

REPORT OF THE STATE BOTANIST

The work of the State Botanist during the season of 1909 has been chiefly devoted to the collection and preparation of specimens of plants for the State herbarium, the preparation of descriptions and in some cases of colored illustrations of those considered new or edible species, the trial of the edible qualities of those which gave promise of edibility and the identification of specimens sent or brought to the office for that purpose.

Specimens of plants have been collected in 10 counties of the State and specimens have been received that were collected in 18 other counties and sent or brought to the office by correspondents or others. These specimens represent 56 species not previously represented in the herbarium and 77 species new to the State flora. Some of these were already present in the herbarium as varieties of species from which they are now separated as distinct. The total additions to the herbarium represent 255 species. The number of contributors is 66. The number of those for whom identifications of plants have been made is 152, the number of identifications made is 1717.

Notwithstanding the unfavorable character of the past season to the development of fleshy mushrooms, five species have been found, tried and approved as edible. This makes the number of New York species, now known to be edible, 200.

The climatic similarity between the growing season of 1908 and 1909 was very noticeable. Both were unusually dry and yet both were marked by an unusually abundant crop of the common edible mushroom, Agaricus campester L. In the latter season, however, the autumnal rains were much less severe and indicated a more favorable condition even for mushroom growth than the former. Besides the common edible mushroom an abundant and quite persistent crop appeared

of the garden mushroom, Agaricus campester hortensis Cke., which ordinarily is rarely seen growing wild. This indicates that gentle rains are better than severe ones, for this variety at least.

No evidence has been seen or received indicating any advance northward in the State of the chestnut tree disease, Valsonectria parasitica (Murr.), which proved so destructive to chestnut trees in the vicinity of New York city and Brooklyn two or three years ago. It is very probable that it has already reached its northern inland limit.

The favor with which the limited monographs of certain New York genera of fleshy fungi has been received has led to a continuance of this work. Accordingly descriptions of the New York species of the closely related genera Inocybe and Hebeloma have been prepared, together with synoptical keys to their subgenera and species.

A list of the genera of fungi previously treated in this way together with references to their respective places of publication, has been prepared by Mr S. H. Burnham, the assistant botanist. He has also prepared a list of the edible, poisonous and unwholesome fungi already published with their bibliographic references.

IV

REPORT OF THE STATE ENTOMOLOGIST

The State Entomologist reports that during the year thousands of young brown tail moth caterpillars in their winter nests were imported on shipments of nursery stock from France. The middle of June a small colony of nearly full-grown caterpillars of this species was discovered at Port Chester, N. Y. The thoroughgoing measures adopted in these instances appear to have resulted in the temporary extermination of these pests from this State.

Fruit tree pests. The most conspicuous injury to fruit the past season was undoubtedly caused by the hordes of plant lice which not only abounded upon apple trees but were exceedingly numerous on the cherry and more or less destructive to the plum. In consequence of the attack on the apple, the trees produced large numbers of small, gnarly fruit, which formed 35 to 45 per cent of the total fruit in some orchards. The exact records of the injury in the two experimental orchards will be

found in the full report of the State Entomologist. One apple grower estimated his loss at 50 per cent. This phenomenal outbreak coincided with unusually cool weather and was undoubtedly greatly favored by climatic conditions. The cigar case bearer was somewhat abundant in orchards in the western part of the State, though it was not so numerous as in 1908. The blister mite continued its injuries of last season and in some localities was much more prevalent, this being particularly true of the Hudson valley.

The San José scale continues to be one of the annoying pests of the horticulturist though progressive fruit growers have little difficulty in controlling it. The general experience with lime-sulfur washes has been highly satisfactory. A number of the commercial preparations of this material have given good results. Fruit growers are now beginning to use this wash in a more diluted form as a summer spray for plant lice and fungous diseases.

Codling moth. The codling moth is one of the very serious enemies of the fruit grower. A series of practical experiments were carried on through the season for the purpose of ascertaining the actual benefit resulting from the application of arsenical poisons, and also the relative efficacy of insecticides applied with a coarse or a fine spray. These experiments were conducted in the orchard of Mr W. H. Hart of Poughkeepsie and that of Mr Edward Van Alstyne at Kinderhook, N. Y. Great care was taken at the outset to secure an infested orchard with an ample number of trees likely to bear a nearly uniform amount of fruit. Each plot consisted of 42 trees, the fruit from the central six alone being counted. The others were used as barriers to prevent the treatment of one plot reacting upon the trees in another. These experiments involved considerable labor, since three sprayings were given in the case of the orchard at Poughkeepsie. It was furthermore necessary to sort and classify over 100,000 apples in this orchard alone. A reference to the data in the full report of the State Entomologist shows a most striking difference between the fruit from the sprayed and the unsprayed trees and indicates in no uncertain manner the supreme importance of thorough work.

Small fruits. The unusually severe injury by the grape blossom midge noted in 1908 was continued the past season though the insect may not have been quite so prevalent throughout the grape belt. The acre of early Moore grapes recorded as seri-

ously injured the previous year was badly damaged the past season. We were fortunate enough in early spring to rear the adult of this fragile midge which has hitherto escaped notice although the blighted blossom buds have been common for several years. Owing to the delay in issuing the report for 1908 it was possible to give, in that publication, a full account of the pest.

The grape root worm, though generally prevalent in the Chautauqua region, has not caused much alarm. This is due in part to a more thorough understanding of the insect and methods of controlling it, and also to better cultivation and fertilization. The latter are important factors in producing vines capable of withstanding injury.

Shade tree pests. The protection of our shade trees from the ravages of insect pests has continued, as it most assuredly should, to receive much attention. It is gratifying to record that the general public is displaying a very commendable interest in this phase of economic entomology. There have been numerous demands for information in regard to these pests and methods of controlling them. The supplying of such information has been an important part of the office work.

The elm leaf beetle has been somewhat prevalent in the Hudson and Mohawk valleys. It caused extensive injury for the first time in the city of Amsterdam and was quite destructive at Schenectady and also at Sandy Hill. There was general though not very severe injury in both Albany and Troy, while judging from reports this pest has been exceedingly destructive to elms on Long Island.

The spruce gall aphid, noticed in the preceding report, has continued abundant and rather injurious in widely separated portions of the State. It is a species which should be watched closely, since it is capable of causing severe damage, not only by destroying the terminal twigs and thus stunting the growth but also, as pointed out last year, by blasting the buds.

The sugar maple borer continues to be a serious enemy of maples. It was particularly abundant the past summer at Fulton, N. Y. A number of trees in that village were badly affected and a few were dying as a result of the recent work of this pernicious borer.

Forest insects. The ravages of forest insects are increasing in severity with the lapse of time. Our forest trees have suf-

fered greatly in recent years from outbreaks by leaf-feeding caterpillars. The snow-white linden moth has been one of the chief offenders. The past season was marked by extensive depredations by this pest. The flight of hosts of white moths about city and village lights, so generally noticed in 1908 was observed the past season.

The small, modest, grayish and olive-brown moths of the spruce bud worm attracted unusual notice in midsummer on account of their prevalence at street lights in a number of widely separated cities. These flights, judging from reports received, have been preceded by serious injuries to spruce trees in the Adirondacks.

The hickory bark borer, a most pernicious enemy of hickories, has been very injurious to the magnificent trees of Prospect Park, Brooklyn. Injuries by this pest have also been reported from the central portion of the State. This nefarious insect has in recent years destroyed thousands of valuable trees in this State. Its potentialities for evil amply justify the prompt destruction of infested trees.

Gipsy and brown tail moths. The appearance of the latter species in this State has already been mentioned and must be regarded as but the precursor of similar visitations. This insect has not, to our knowledge, become established west of the Connecticut valley, and it is to be hoped that the repressive measures, prosecuted jointly by the State of Massachusetts and the federal government will result in keeping this destructive form at a distance for some years to come.

The finding of numerous winter nests of the brown tail moth upon imported French stock last winter resulted in our conducting a series of experiments for the purpose of determining the efficiency of hydrocyanic acid gas as an agent in the destruction of the caterpillars. Though this most deadly gas has given excellent results with other species, it proved of no service in killing brown tail moth caterpillars within their nests, and could not be relied upon to destroy free caterpillars in a dormant condition at any reasonable strength and without an unduly prolonged exposure. The details of these experiments, showing the unreliability of this gas, are given in the full report of the Entomologist. On the other hand, dipping the caterpillars in a miscible oil placed upon the market under the commercial name of scalecide, was invariably followed by death.

There is still no authentic record of the gypsy moth having become established in New York State. The pest has not made its way nearer than the outlying small colonies known to exist at Springfield and Greenfield, Mass. The Entomologist has sent out a number of warning placards to places where these insects would be most likely to become established and as yet nothing suspicious has been discovered.

Miscellaneous. The large, steely blue insect known as Say's blister beetle was unusually abundant in the vicinity of Albany and occasioned some anxiety lest it prove a serious pest. There was a restricted outbreak of the army worm at Oakdale. Conditions were evidently rather favorable for more extended mischief by this insect, since the Entomologist found the caterpillars at Port Chester numerous though not very evident on account of the large amount of provender upon which they could subsist.

House fly. This insect, with its acknowledged potentiality for evil, is one of the most momentous of our injurious species. The present great interest in the house fly and methods for its control led to the devising of a vivarium or special house for the purpose of testing the behavior of this insect in relation to light and in particular to ascertain whether darkness or partial darkness could not be used as a barrier to keep this ubiquitous creature from breeding materials of various kinds. The house was a light-proof structure with partitions arranged in about the same way as those in the photographer's dark room, and flies were given a free opportunity to enter as far as they would with a constantly decreasing illumination and deposit eggs upon moist horse manure. The details of the experiments, given in the full report of the State Entomologist, show that this insect will not invade moderately dark places for the purpose of depositing eggs. It should be comparatively easy and very practical to store all such materials in dark or nearly dark places.

Gall midges. The work upon this group has been pushed as rapidly as possible consistent with the discharge of other duties. We have been able to make material additions to our knowledge of the biology of the group. This was particularly marked in the case of Sackenomyia, originally described from a female taken on the wing and now represented in addition by two reared species, of which both sexes, larvae and galls are known. The life histories of a number of species of Caryomyia, forms responsible for the peculiar and varied hickory leaf midge galls,

have been worked out. Likewise, a number of species of Cincticornia, a genus confined to oak, has been reared and some very gratifying data obtained. These by no means exhaust possibilities with this group, since material has come in so rapidly in recent months that it has been practically impossible to classify it adequately and at the same time collect or rear additional forms. Over 50 species have been reared during the year, most of them new and making a total in the collections of probably over 800 species, about 350 having been reared. This large number of specimens, in some instances species are represented by a hundred midges, is practically classified and only requires a relatively small amount of descriptive and collative work before being made available to the public.

Special acknowledgments in this connection are due Miss Cora H. Clarke of Boston, Mass., who has collected and forwarded to us large series of galls from which we were able to rear a number of previously unknown species. The care of this material devolved largely upon Mr D. B. Young, who has met with exceptional success in rearing the flies. Miss Fanny T. Hartman has assisted in caring for the biological material and has made excellent microscopical mounts of many of these extremely delicate midges.

Publications. Many brief, popular accounts dealing with injurious insects have been prepared by the Entomologist for the agricultural and local press and a few notices of more than general interest have been disseminated as press bulletins or through the agency of the Associated Press. A comprehensive popular bulletin on the *Control of Household Insects,* made advisable by the recent great advances in our knowledge of the relation of insects to the dissemination of disease in particular, was issued in May and is now, due to the great demand for such information, practically out of print. The report for last year, owing to delays incident to publication, was not issued till the last of the present year. A popular account summarizing one phase of our studies of gall midges and entitled: "Gall Midges of the Goldenrod," appeared in the *Ottawa Naturalist* for February. Biological data and brief descriptions of nearly 50 reared species of Cecidomyiidae were published in the issue of the *Journal of Economic Entomology* for August.

Collections. The additions to the collections have not been very extensive, since the amount of material already at hand de-

mands the expenditure of much time before it can be properly classified. Particularly gratifying additions have been made by rearing large series of Caryomyia, Cincticornia and Sackenomyia, the biology of these genera being previously unknown.

The general work on the arrangement and classification of the collection has been pushed as rapidly as possible. D. B. Young has identified practically all our species of Bombylidae, has done considerable work upon the Empididae and made substantial progress in classifying the Sapromyzidae, the Tabanidae and the Sciomyzidae. Mr Young is also responsible in large measure for the preparation of the list of insect types in the New York State collection given elsewhere. Much of Miss Hartman's time has been devoted to the care of breeding material, to mounting and labeling, to interpolating specimens, particularly Microlepidoptera in the general collections, and to bibliographic work.

Several greatly enlarged models representing injurious insects or portions of such forms have added very much to the educational value of the entomologic exhibit. A list of these models is given in the full report of the State Entomologist. This is only the beginning of what should be done along this line, since if one may judge from the work of other museums, the practical value of the exhibit collections has been greatly enhanced by accurate and tastefully executed models of important species. It is to be hoped that provision can be made shortly for the continuance of this work along broad and comprehensive lines.

General. As in past years, the work of this office has been greatly facilitated by identifications of certain species through the courtesy of Dr L. O. Howard, Chief of the Bureau of Entomology, United States Department of Agriculture and his associates. Several correspondents have been of material service in securing valuable specimens of one kind or another and as heretofore there has been a most helpful cooperation on the part of all interested in the work of this office.

V

REPORT ON THE ZOOLOGY SECTION

During the past year, in accordance with the policy stated in the last report, attention has been given entirely to the collections, and while the actual additions are not as great as might be desired, considerable work is under way that should be completed during the coming year.

The large group of black bear mentioned in my last report has been completed and the result makes a very effective exhibit. Through the courtesy of Pres. William J. Milne it has been temporarily placed in one of the new buildings of the State Normal College and will remain in its present quarters until the completion of the Education Building gives it a permanent home.

A group of moose has also been obtained consisting of a bull, a cow and a yearling. This is at present in storage as we have no place suitable for exhibiting it.

The taxidermist has prepared a habitat group of mink showing the animals by a pool of water in the foreground, the background representing an Adirondack scene which was painted by Mr D. C. Lithgow.

A group of sunfish and perch, of the same type, is also ready. This exhibits the fish swimming in the water among pond lily stems and weeds. The pond lilies themselves are shown on the surface of the water. This is the only fish group in which a successful attempt has been made to show both the surface of the water and a section through it. The exhibition of these groups has been delayed awaiting the procuring of cases, but they should be ready for public display by the beginning of the year.

The museum has also secured the necessary material for groups of porcupine, black rats, white-footed mice and several birds; while groups of wolf, puma, fisher and Canada lynx are in course of preparation.

The museum has been particularly fortunate in securing from Mr Austin Corbin, president of the Blue Mountain Forest Association, the promise of the material necessary for making up a group of buffalo, which has already been redeemed in part by the gift of two specimens from his herd. This opportunity is taken of publicly expressing an appreciation of Mr Corbin's kindness and generosity in this matter.

The ornithological collection which is in far better and more complete condition than the other zoological sections, has been allowed to remain except for such specimens as were kindly furnished by friends of the museum.

The taxidermist has also been working upon wax casts of some of the batrachians, two of which are now on exhibition, namely, one of the spring peeper and one of the common wood frog. This method of exhibiting these soft bodied animals seems as satisfactory as any yet devised and the Zoologist hopes to have a series of these casts completed during the coming year.

Considerable work has been done on the collections of Mollusca with the end in view of making them accessible. This work includes the making of a card catalogue, as the museum possesses much molluscan material, including the very valuable Gould collection of types, and it is very desirable that this be so arranged and indexed as to become available to those interested in the subject.

Monograph of the Mollusca. A very wide public interest exists in the terrestrial, fresh-water and marine *mollusks* and to meet demands for exact information as well as to bring our acquaintance with the New York molluscan fauna up to present standards, a monograph of this group was inaugurated a few years ago. Progress on this work was made, though slow, and at the present time it is in charge of Dr H. A. Pilsbry of the Academy of Natural Sciences, Philadelphia, a leading authority on the Mollusca.

Dr Pilsbry's work thus far has been directed almost entirely to certain groups of small or minute forms upon which nothing had been done at the time the monograph was placed in his hands, either in manuscript or illustration, viz, the *Pupillidae,* the *Zonitidae,* the smaller *Endodontidae,* the genus *Strobilops,* the *Valloniidae* and *Cochlicopidae.* The work on these groups is practically completed except for the subject of distribution. It is hoped that by collections and correspondence, substantial additions to the New York records of many species may be made, and some additional species may be found in the State. Several species not hitherto reported from New York have already turned up in the material examined.

Considerable work has been done in tabulating existing records, with the view of ascertaining what districts in the State have not been closely examined for recent mollusks.

In appropriate connection with this work on the *Mollusca* a preliminary investigation has been undertaken of the occurrences of pearls in our streams and lakes and a general inquiry into the possibilities of the development of this interest and expansion of the pearl shell industry. The presence of pearls in our waters is less a matter of record than, at least so far as recent occurrences are concerned, of report and news. Their discovery, however, is ancient. The fresh-water clams which are known as the Unios, Anodontas etc. occur very freely in all our lime-bearing waters and it is well known that these mollusks were used for food by the aborigines, as witnessed by the shell heaps which have been

found near Binghamton and in other inland localities. The Indians also recognized and valued the fresh-water pearls, for these have been taken sometimes in large numbers from Indian graves, usually perforated for stringing on a necklace and "more than three score and ten" pearls of unusual size, now unfortunately discolored and partially decomposed, were taken from one of the burial sites in the Genesee valley. The list of these occurrences among the excavated remains of the aborigines is rather surprising.

The earliest historic records of the discovery of pearls here are of altogether recent date. The finding of the Queen pearl at Notch Brook, N. J. in 1857 is usually regarded as the first noteworthy discovery of the kind in recent times. In 1868 pearls were found in the fresh-water clam shells of the Mohawk valley near the city of Rome and one of them is known to have brought the price of $100 in the market.

The lakes and streams of central, northern and northeastern New York, specially those draining into the St Lawrence river, have yielded the largest, finest and most numerous pearls. 68 grains is the weight of the largest known New York pearl. It was found in the Grasse river in 1897 and sold for $800. Most of the pearls from northern New York are of a peculiar translucent white, often highly lustrous. Others are of a light pink or rose color. As a rule the pearls of the streams are more abundant and of finer quality than are those of the lakes, the latter being usually milky in color, lacking in luster and hence of inferior quality. While it is not at all likely that these pearls are now to be had in sufficient quantity as to justify any extended operations that would involve much expense, yet it is most desirable to have definite data in regard to their occurrence and the conditions governing them. Pearl culture has been attempted with various degrees of success in many countries, though seldom on the fresh-water mollusks. The results attained do not give promise of culture pearls of high quality, but nevertheless they have had a commercial value, and may, even here, be made to form an important accessory to the cultivation of the shells themselves.

Another economic phase of this subject is the market value of certain varieties of these clam shells for the manufacture of pearl buttons. There are at present more than a score of button factories in the State which annually consume thousands of tons of shells in their operations. At present their supply of fresh-water shells is almost entirely obtained from the Mississippi

valley at considerable expense, and the expense is further augmented by the extreme percentage of waste of the raw material in the process of button making. Indeed it often runs as high as 90%, and averages more than 80%, upon all of which transportation charges have to be paid from the western source of supply. It is not unlikely that the natural supplies of the New York streams would help to alleviate this situation, as experiment has shown that several of the New York varieties are suitable for button manufacture. There is no obstacle to the artificial propagation of these varieties in the streams that are by nature specially adapted to their growth. Indeed it is altogether as practical a proposition as the artificial propagation of fish. Probably all of the fresh-water mussels in our rivers are or may be capable of pearl production, but it is an interesting fact that the three or four varieties most suitable for button manufacture are also those which have yielded most frequently the best grades of pearls, and it is also entirely reasonable to assume that the propagation of the pearls themselves is within the scope of artificial methods, though so far as experience in other countries in this artificial creation of pearl secretions has gone, the results are of inferior grade. It follows, however, as a natural conclusion that if the number of mussels with pearl-producing possibilities is increased by artificial propagation, the chances are also greatly augmented for increase in the production of the pearls themselves.

This line of investigation has been taken up by Prof. Philip F. Schneider and will be continued in the hope of bringing it to a conclusion that may justify recommendations of public usefulness.

Birds of New York. In several previous reports I have made reference to progress on a monograph of the *Birds of New York,* last year giving a summary statement of the contents of the first volume. This volume is now leaving the press. Volume 2 is complete in manuscript and its printing will be forwarded as rapidly as the character of the work justifies.

On account of the widespread interest in this publication and in view of the general demand for copies of it, this occasion is taken to announce that, in accordance with the requirements of the Department, the work will be held for sale at the following price:

Volume 1 Introductory chapters; Local lists, Water birds and Game birds (Pygopodes, Paludicolae, Limicolae, Gallinae and Columbae), 42 plates in color.....$3
Volume 2 Land birds (Accipitres, Striges, Coccyges, Pici, Macrochires and Passeres), 60 plates in color.....$4
Purchasers of volume 1 will be at liberty to buy volume 2, when issued, at the price of $3.

VI

REPORT ON THE ARCHEOLOGY SECTION

Collecting in all of the various branches of this section of the museum has been necessarily subordinated to the work of procuring models and superintending the work of casting the figures and making the preliminary field sketches for backgrounds for the ethnological groups. The pressure of this undertaking made it impossible for the Archeologist to engage in active field work in archeology, although he made preliminary surveys of certain sites in central and southeastern New York.

In September the assistant in archeology was sent to Port Jervis to excavate the site of a Minsi village and burial ground which the Archeologist had previously examined at the suggestion of the Director. Little or nothing is known regarding the archeology of the Minsis nor was it possible to determine from an examination of the Port Jervis site much concerning their culture except in the line of their mortuary customs.

The Van Etten site, the site of the Minsi village and burial place is found on the Levi Van Etten farm on the east bank of the Minisink river, 2 miles from Port Jervis. It has been known for many years to the people of the region. Tradition as well as material evidence kept it constantly in the minds of interested persons. The annual spring freshets of the Neversink cut away the alluvial hill upon which the burial ground was situated and bones with accompanying relics would roll down the eroded bank and either be caught upon the sand bars or fall in the waters to be swept away and lost forever. A considerable number of collectors have visited the site and picked up the relics brought to light by rains and flood and several have excavated certain portions of it but with little success.

Excavations conducted during the months of September and October 1909 by the assistant in archeology resulted in the discovery of 30 graves and several hearths and refuse pits. The

latter contained little of interest, only a few potsherds and rude flints being found in them.

An examination of the burials proved that the Minsis had for some time been influenced by the white men about them. Some of the skeletons seem to have been buried in rough wooden boxes. The position of all skeletons found in what appeared to be the remains of boxes was the extended position instead of the flexed position generally found in old burials in this State.

Most of the objects found in the graves were of European origin. These objects include beads of several sizes and shapes, brass and iron finger rings, brass bracelets, brass bells of two forms, one bronze soup spoon, one clay pipe stamped R. Tippet, and brass buttons. The aboriginal artifacts found in the graves were all shell ornaments, probably pendants or gorgets.

Several of the skeletons present interesting features for study. There are several fractures and cases of ankylosis worthy of careful examination. Osteological studies of these skeletons are reserved for a future time.

The skulls are unlike any others which are found at present in our collections. They are flattened at the occiput evidently by artificial means, probably in early infancy by the agency of the baby-board. This occipital flattening gives the skull, as viewed from the front, a peculiar bulging appearance at the back.

An interesting series of stone articles from the lower Hudson valley has been received from the American Museum of Natural History in exchange for a collection embracing a number of duplicate specimens from western New York. The Hudson valley collection contains some good specimens of chipped and polished stone articles.

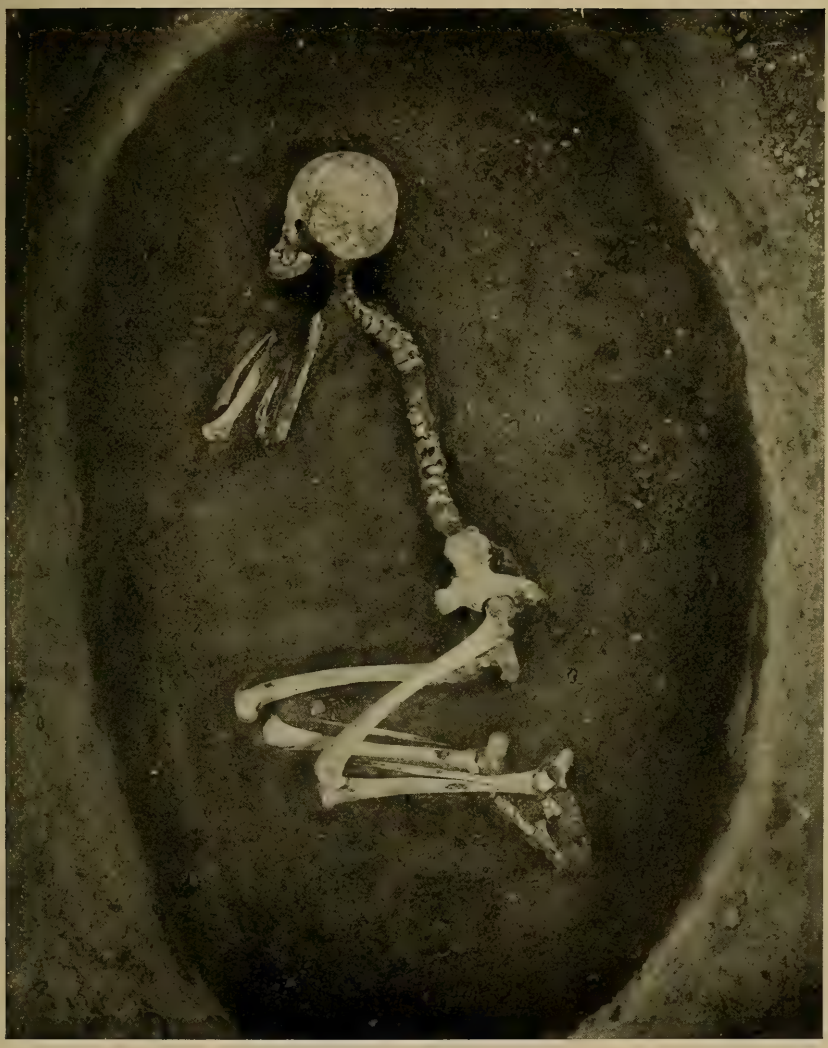
Through the activity of Mr D. D. Luther, the field geologist, an unusually good lot of articles has come to us from two ancient graves on the east slope of Bare hill, Canandaigua lake, near the village of Middlesex. The collection includes a knife of rhyolite, 10 inches in length. The chipping is good and the knife thin considering the poor quality of the material. With this knife was found a rude pipe of pottery. It has no decorations. In the same grave was a long string of shell and elk tooth beads, a copper chisel and two finely made stone tubes. A second grave contained a broken tube and a broken bar amulet. All of these objects are relics of a Pre-Iroquoian people and are similar to specimens found in mounds.

General view of the Minsi burial ground near Port Jervis. The expedition tents are shown in the middle distance.

Plate 14

Landslip caused by the underwashings of the substratum of sand at the water level. The landslides here frequently exposed skeletons and relics. The amount of land lost in five years can be measured by the fence posts in the middle distance.

Plate 15



Typical aboriginal burial of the Minsis. The camera was pointed directly down and over the grave. No specimens were found in this burial.

Extended position which characterized all burials where European objects were discovered with the skeleton. The beads shown on the neck are large opalescent glass trade beads.

Grave 28, Port Jervis Minsi site. Child burial, extended position. The objects shown in the grave with the skeleton are, a bronze spoon, a brass bell and a shell ornament.

The Minsi burial ground is situated on the terrace above the flood plain of the Neversink river. The burials were found along the edge of the terrace and the village site was farther back.

Ethnology

In collecting ethnological specimens the policy of the Department is to acquire all that illustrates the Iroquois culture. Many of the specimens are old and have been preserved for years as heirlooms or keepsakes. Some of the specimens however are absolutely new, but their value is not lessened thereby. Such objects serve to illustrate the persistency of Iroquois material culture and are similar in all respects, save age, to specimens which have been kept through the years. Our aim is not to collect objects merely because they are relics, but to collect specimens which illustrate a material culture.

Some of the old arts of the Iroquois exist merely in the memory of a few aged persons and we have been seeking to revive these arts where we have few or no specimens of them.

Silver working and certain forms of basketry, weaving, porcupine quill and moose hair decoration, skin working, carving and beading have become almost lost arts and it is hoped that a revival of these arts by a few individuals will furnish our collections with certain specimens now impossible to obtain. If we were merely collecting antiquities this policy would not be feasible.

Notable additions to the collection. Several masks of the False Face Company (Ja'di'go^{n}'sa sho''o') have been added to the collection. Some of these are of unusual interest. One large mask representing the "ash blower" was purchased by the Director. This mask is one of the old and unusual varieties. Other masks are a "doctor" face, a "wolf mouth" and one having the eye-plates cut in semilunar form and the lips in the form of the figure 8 laid horizontally. The three masks last mentioned were obtained on the Cattaraugus Reservation during the midwinter ceremonies of the Senecas in January 1909.

There are yet many facts to be collected before a complete description of the Iroquois False Face Company can be written. This statement indeed holds good for the various folk societies. The Archeologist is using every opportunity to get at the facts and already has a large amount of data on hand.

During the Strawberry Thanksgiving in late June, the Archeologist made a special effort to get some additional information and succeeded in getting photographs of the officers of the False Face Company carving a "medicine" or "doctor face." Such faces are carved upon a living basswood tree and when com-

pleted the tree is chopped down. Its life is believed to enter the face which is chopped from the trunk and finished by the carver. During the process of carving an officer of the company throws tobacco, oyĕñ′kwa‘o^{n}′we‘, (Nicotina rustica) upon a small fire and chants the rite that makes the face a living potency. A photograph of the carving ceremony is shown in plate 18. The Archeologist obtained the false face on the tree-trunk carving and added it to the State Museum collection. So far it forms a unique specimen in collections of Iroquois artifacts.

One other carving, that of a wolf head used for placing over a door, was purchased. The head represents the token of the mother and children living within the house.

The Senecas have not used bark barrels for storage for more than 40 years. Barrels of elm bark once formed the chief means for storing corn and other provisions as well as goods of other kinds. Early in the year one of these elm bark storage barrels was found on the Cattaraugus Reservation and purchased by the Archeologist. It had recently been made by a Seneca whose mother had instructed him in the all but forgotten art. It is about 18 inches in diameter and 30 inches high and has a cover. The bark is sewed with the inner bark of the elm. In the entire object there is not a nail or a peg. The Algonquin Indians of Canada, particularly the Abenakis make barrels similar to this of birch bark but they are not as strong as the elm bark barrels of the Iroquois. A birch bark storage basket was purchased for comparison.

A good set of baskets used in planting, harvesting and food preparation was purchased from Mrs Edward Cornplanter of Newtown on the Cattaraugus Reservation. A paddle which was included in the collection had been promised for several years. This paddle had a number of grotesque figures carved upon the handle but some of the most significant from the standpoint of symbolism had been cut away.

An interesting war club made from the knot of a sapling root was secured from the Senecas. It has carved upon it representations of all the clan animals and two Indians engaged in combat.

Other unusual pieces are an Eagle Society speaker's pole, examples of modern silver work, wooden spoons, and several beaded articles, two of them old and very fine. Several charms and amulets were added to the already interesting series.

Plate 18

False faces are carved upon the living trunks of basswood trees by a wood carver chosen by the False Face Company. While he carves an officer of the company chants the carving song, casting native tobacco on the ceremonial fire as he sings. When the mask is rudely formed the tree is cut and the mask taken from the log to be finished elsewhere.

Folklore. Work in recording the folklore and ceremonials has been retarded this season by activity in other lines. Some notes, however, were taken and a very important manuscript secured through the courtesy of Rev. A. J. Farney of Ohsweken, Ontario. This manuscript is the version of the code of Daganowida, the founder of the Five Nations' League as adopted and written by the Six Nations' Council. The story describes the meeting of Daganowida and Hiawatha and gives a history of their subsequent activities. It concludes with a version of the Condolence ceremony extracted verbatim from Horatio Hale's *Iroquois Book of Rites,* a seeming tribute to the accuracy of Hale's work.

There is much work in the line of collecting lore of this character. It is becoming more and more difficult to get. The old people who have memorized the various rituals and legends are rapidly passing away and but few of the younger people have taken the pains to burden themselves with a knowledge of the old ways of their fathers. Some knowledge of this vast unwritten literature will undoubtedly pass down to the descendants of the New York Iroquois but much will be lost unless provisions are made for its preservation within the immediate future.

Public interest. Interest in the present and past Indian life of our State seems to be fast increasing. Students are turning with renewed activity to the subject of the ethnology of the New York Indians. Artists and sculptors are seeking accurate information in regard to the costumes and the customs of the Iroquois. Many hundred inquiries along these and similar lines have been directed to this section of the State Museum.

With a limited exhibition space, limited quarters, insufficient equipment, and the great bulk of our material in storage, we have been at great disadvantage. Students from many quarters representing well known institutions have made personal visits to our office and collections only to be disappointed in a large measure because of our limitations.

During the fiscal year just passed special attention has been directed to the Indians of our State through various historical celebrations, and yet with a great store of material, consisting of both facts and relics of Iroquois and Algonquin culture we had neither facilities nor time for bringing these things to public notice, so great was the demand of other things.

The Governor Myron H. Clark Museum of Iroquois Ethnology

To illustrate the culture history of the Iroquois we have designed a series of six ethnological groups.

To formulate plans and to select proper models, sites for painting and to carry out the numerous details incident to so large an undertaking has consumed the greater part of the past 12 months and has required constant activity.

The object is to portray in a material way the characteristic habits of Iroquois life. These life activities it will be realized in general were similar to those of other peoples living in the eastern forest areas and in the same cultural stage.

Ethnological groups have been installed in most of the larger educational museums in the United States and elsewhere and have universally proven most instructive exhibits. They add an element of realism impossible to secure by any other method. A group of casts properly arranged shows at a glance what would take many pages to describe and a great deal of shelf room to illustrate. The virtue of such groups is that the costumes, ornaments, implements and utensils are all properly correlated and their uses shown.

The most primitive activity of any people is the food quest. The greater part of savage man's food was secured by hunting. The hunting stage is one of the most romantic in the development of mankind. Its influence is so strong because of its character, and its period so extended in the history of all races that it has left an indelible impress upon the minds of all races, even those whose cultural stage is far above it. To this day the gratification of the hunting instinct gives enlightened men a great amount of pleasure.

A second activity of races is warfare. The conflict of man with man in warfare has gone on for thousands of years and until now there has been no thought of its abandonment. Warfare, cruel as it is and destructive as it is, has seemed a necessary part of human development. Art and inventions, heroism and intellect seem to have been stimulated by it. This is probably because each party in the conflict saw his own life and the existence of his tribe or nation in immediate peril and sought every means to avert it.

The logical outcome of any emergency is a council. Men congregate to discuss the means of warding off danger, defeating

enemies, or accomplishing desires which affect the entire body of people. The council would thus beget leadership and government.

Personal welfare, primarily, and group welfare, secondarily, being the consuming desire of men, every means real or fanciful, is sought to secure its attainment. A belief in supernatural agencies and the development of men who assume and are assumed to know something of these supernatural potencies, gives rise to certain rites and ceremonies thought to be conducive of welfare — luck or health as the case may be. Ceremony and religion thus enter into the life of ethnic groups with all their concomitants.

Social life so far advanced presupposes the existence of productive arts, that is to say industries by which implements, utensils, weapons, clothing, ornaments and other useful objects are manufactured. The character of these artifacts and of the methods of their production differ as the cultural stage, the cultural degree and the individual group development differ.

Up to this point the social group has nothing to localize it. The group may be nomadic for neither hunting, warfare, counciling, ceremony nor industry postulate sedentary life. Such life commences with some activity thought vital to group welfare and inseparable because of its character from a locality. Agriculture is such an activity and in agriculture we have the basis of group stability and group sedentarism. It confines a group of families to a certain general locality for at least a season. It creates community interest and crystalizes the group. With this development the people would cling to a locality for an appreciable period unless driven out by hostile groups or other causes.

In the lower stages of culture where agriculture has developed we find that villages take growth. Instead of a place of wanderers' tents or hunters' tepees we find houses of more or less stability. Trails or roads are built from village to village. Travel and traffic commence; civilization is now a mere matter of growth.

Upon the foregoing hypotheses the Archeologist has planned the character of the figure groups by which the ethnology of the Iroquois will be illustrated. Casts of the Iroquois Indians in various positions are being made and arranged in groups. These groups will illustrate the various life activities incident to the Iroquois culture. Our groups will differ from other ethnological groups in other museums in that a cycloramic painting will form the back-

ground. Months of study and visits to large museums have been made to establish the feasibility of this plan. The cases in which the groups are to be installed have a front of a little more than 20 feet and a hight of about 17. The depth of the case and the foreground in which the group is to be installed is about 12 feet. The glass front will be about 9½ feet in hight and 15 feet long. The case is so planned that when the visitor views the group no part of the interior of the case is visible. The point where the painting meets the top can not be seen, neither can the points where the sides meet the front of the case be observed. The object is to create the illusion that one is looking out through a large window at nature itself. The painting is made in such a way that the foreground with its artificial foliage and natural work meets almost imperceptibly with the painting — one seems a continuation of the other.

To illustrate the activities of hunting six Seneca Indians were selected as models and brought to New York city where they were posed in characteristic attitude and cast in plaster. Such figures show the tree chopper with his stone ax busy felling a tree by the charring and chopping process, the old hunter bringing in a deer, a boy with his traps and birds he has killed, a hunter with bow pulled back in the act of shooting a flying partridge, and two women one of whom is skiving a deer pelt and the other cutting venison into strips for jerking. These figures it must be borne in mind are exact casts from life, limb for limb, feature for feature, and even pore for pore, so exactly does the plaster reproduce the living model. As a background for this group of Seneca hunters a scene on Canandaigua lake was chosen. The Archeologist in company with an artist made a trip up the lake above mentioned and chose a site where a good view of Bare hill, the ancestral hill of the Senecas, might be had. Early Seneca history and tradition is so inseparably interwoven with associations with Bare hill and Canandaigua lake that it seems most appropriate to employ the scene as a background for the group of "primitive" Senecas.

As hunting is the most primitive activity of savage life, the hunting group will be the first of the series.

The second group for which casts have been made is that which illustrates some of the characteristic war customs of the Mohawks. The group is called *The Return of the Warriors.* It embraces six cast and modeled figures with others in the painted background. The group shows the advance party of warriors bringing in two

Algonquin captives. One of them labors under a heavy load of booty and expedition impedimenta and is being urged on by a gigantic Mohawk. An old sachem is kneeling on one side and examining a pack of skins, trinkets and seeds which has been brought in by the party but his interest is diverted to one of the captives who has thrown down his burden in defiance. A warrior with uplifted club is about to dispatch the haughty captive when a matron from the village asserting her right to adopt touches him and holds out a protecting hand. The angered warrior relaxes and has rested his club on his shoulder. In the presence of a woman his emotion is concealed.. His brow only shows a questioning wrinkle. Another warrior who has seen the affair turns on the brow of the hill and haloos down the valley to the chiefs who are leading the rest of the warriors back to the stockade.

The scene is laid at Tionnontogen the capital of the Mohawk Nation in 1667. Tionnontogen was the town and stockade destroyed by De Tracey. The site of this old stronghold is found on the Mitchell farm near Sprakers Basin, Montgomery co. The old village and stockade was situated on a little plateau that juts out into the flood plain of the river. On one side is a deep ravine that forms the east bank of Flat creek. Copious springs of pure water make the place an ideal one for an Indian town and the steep hills on three sides render it a good site for a fortification. The site of Tionnontogen commands one of the finest views of the Mohawk valley to be had. Just to the east, the high limestone "Noses" bar the vista, but to the north and west the river, the hills and the valley may be seen stretching far into a blue mist that covers the distant horizon.

There are many romantic events associated with Tionnontogen and the deep ravines and rugged hills and great stone "Noses" which give the spot its name only intensify the romance.

In making the sketches for this scene the artist took his position on a jutting ridge just over the ancient site. The scene is one of late autumn and in the large painting the artist will attempt to show it as it might have been when it was the center of Mohawk life.

To get casts of the Mohawks the Archeologist went with the sculptor to the Six Nations Reservation in Ontario where a month was expended in selecting proper models and in making molds.

Casts for a third group, the sixth in the series, were made during September. This group will portray the agriculture and harvesting activities of the Seneca-Iroquois. An old man strolls in from the right, holding his clay pipe in one hand and a bunch of

Indian tobacco (Nicotina rustica) in the other. Before him is a group of women engaged in gathering and preparing the crops. One is braiding corn, one is shelling beans and putting them in a bark storage basket, one is baking bread and watching a pot, another is pounding meal in a wooden mortar, and still another is carrying in a heavy load of corn. The scene is laid on the flats of the Genesee just below Squakie hill near Mount Morris, Livingston co. The painted sketch which was made on the spot shows a cornfield in the foreground, the river to the left with the cliffs just beyond. To the right is the steep slope of Squakie hill covered by oaks, hemlocks and maples, all resplendent in their brilliant autumn foliage. The spot is one associated with the later history of the Senecas and by some is said to have been regarded as their Olympus.

The Senecas were always extensive agriculturists and today preserve certain primitive features of agriculture better than the other Iroquois. The flat lands of the Genesee were cleared in wide tracts and given up to their great cornfields. These reasons with others lead to the choice of the Senecas and their beautiful valley, the Genesee, as the actors and the scene for the harvest group.

The Onondaga Council group, the Oneida Arts and Industry group and the Cayuga Ceremony group are still undeveloped beyond the plan stage.

The work of making and superintending the making of these remaining groups will consume another year. There are many unavoidable obstacles which impede progress of this undertaking and yet to those quite familiar with similar work our progress has seemed rapid.

It is difficult to get proper models, especially females whose natural modesty leads them to shrink from the casting process. The eight female figures which we have are without doubt the only life casts of Iroquois women ever made. Our casts of male figures likewise are, for the most part, phenomenally expressive.

In carrying out our plan the idea is to have every possible feature of it genuine. The casts are to be genuine life casts of Iroquois Indians, their costumes genuine Iroquois costumes, Iroquois made and decorated, and the paintings are to be accurate representations of scenery intimately connected with Iroquois history.

When installed each group as viewed from the front of the case will present the illusion of an actual view of nature. The foreground will be made to look as natural as possible by expert

leaf makers. Each group will form a unit around which will be clustered cases of implements, ornaments or utensils, the use of which is shown in the group.

The whole scheme when completed will furnish a comprehensive picture of Iroquois life in the precolonial period so far as that life can be interpreted through history, tradition and the present day survivals of the Iroquois culture.

For some years past the remains of the ancient Indian settlements in the Naples valley near the south end of Canandaigua lake, have been closely studied by Mr D. D. Luther, who has, in spite of the fact that the fields where these settlements stood have been ploughed over for more than a century, been able to acquire very positive evidence of their extent and of their early age. Mr Luther has given an account of this village on following pages of this report.

VII

PUBLICATIONS

A list of the scientific publications issued during the year 1908–9 with those now in press and treatises ready for printing is attached hereto. The publications issued are 13 in number on a variety of topics covering the whole range of our scientific activities. They embrace 1780 pages of text, 171 plates and 22 maps.

The labor of preparing this matter, verifying, editing and correcting is onerous and exacting. Taken altogether it excellently indicates the activity and diligence of the staff of this division.

Annual report

1 Fifth Report of the Director, State Geologist and Paleontologist for the fiscal year ending September 30, 1908. 234p. 39pl. map.

Contents:

Introduction
I Condition of the scientific collections
II Report on the geological survey
Geological survey
Seismological station
Mineralogy
Paleontology
III Report of the State Botanist
IV Report of the State Entomologist
V Report on the zoology section
VI Historical Museum
VII Archeology
Ethnology
VIII The protection of natural monuments

Contents (continued)
IX Publications
X Staff
XI Accessions
One Hundred Years of New York State Geologic Maps 1809–1909. HENRY LEIGHTON
A Peculiar Landslip in the Hudson River Clays. D. H. NEWLAND
Some Items Concerning a New and an Old Coast Line of Lake Champlain. GEORGE H. HUDSON
Types of Inliers Observed in New York. RUDOLF RUEDEMANN
Some Marine Algae from the Trenton Limestone of New York. RUDOLF RUEDEMANN
Some Parallel Groupings of Calcite Crystals from the New Jersey Trap Region. H. P. WHITLOCK
The Last of the Iroquois Potters. M. R. HARRINGTON
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Memoirs

2 No. 9 pt 2 Early Devonic of New York and Eastern North America. By John M. Clarke. 250p. 36pl. 4 maps.

Contents:
Introduction
Dalhousie formation
Description of species
Arenaceous Devonic faunas of Somerset, Piscataquis and Penobscot counties, Maine
Description of species
Devonic faunas of the Chapman Plantation, Aroostook county, Maine
Description of species
Early Devonic in eastern New York
Notes on the Oriskany fauna at Highland Mills
Table of the Oriskany fauna of New York-New Jersey region
General conclusion
Supplementary notes
Fault and infall at L'Anse au Sauvage on the Forillon, Gaspé
Crinoid from Grande Grève limestone
Explanation of plates
Index

Bulletins

Geology

3 No. 126 Geology of the Remsen Quadrangle. By W. J. Miller. 54p. 11pl. map.

Contents:
Introduction
General geologic features
Topography and drainage
Rocks of the region
Structural features
The Paleozoic overlap
The Precambric surface
Absence of the Dolgeville (Upper Trenton) shales
Glacial geology
Economic geology
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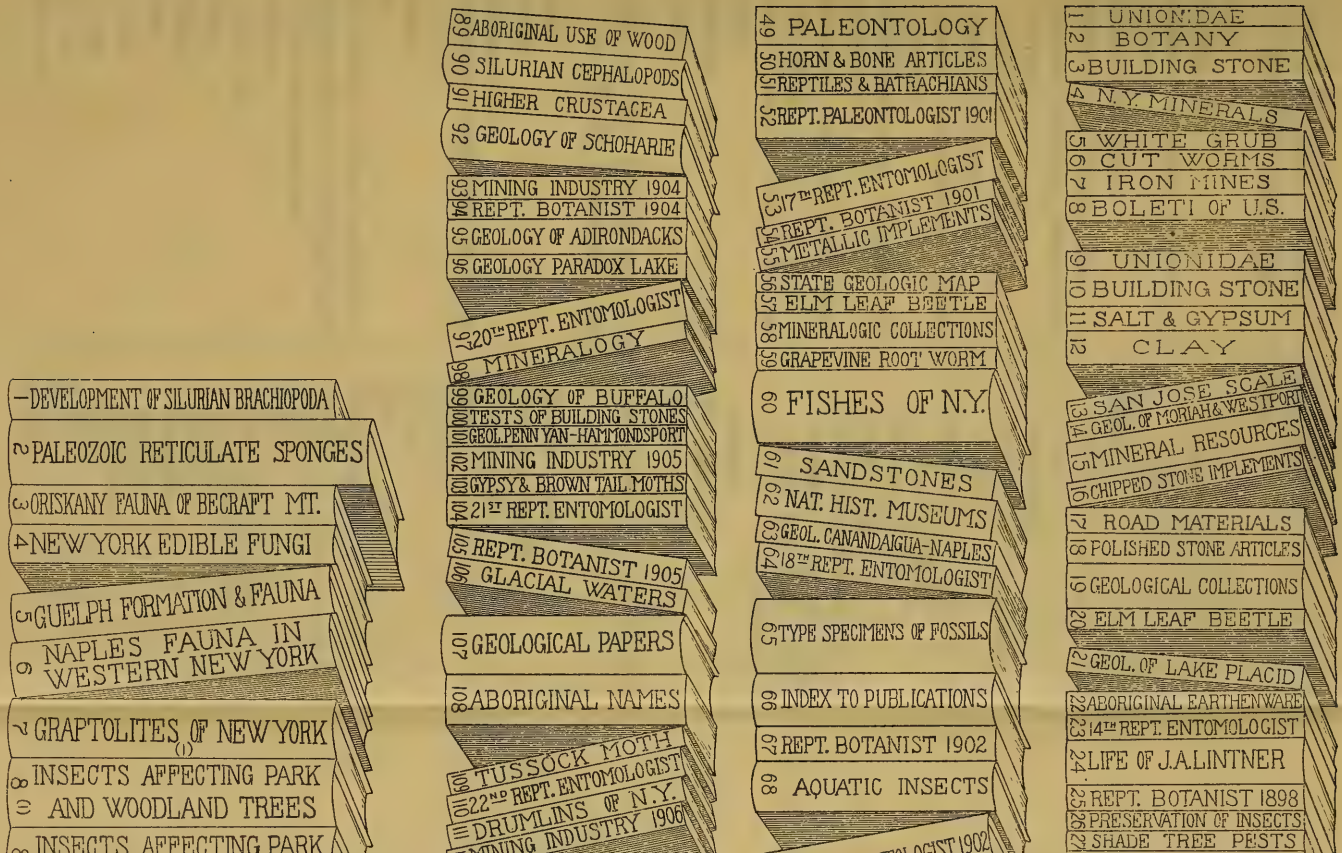
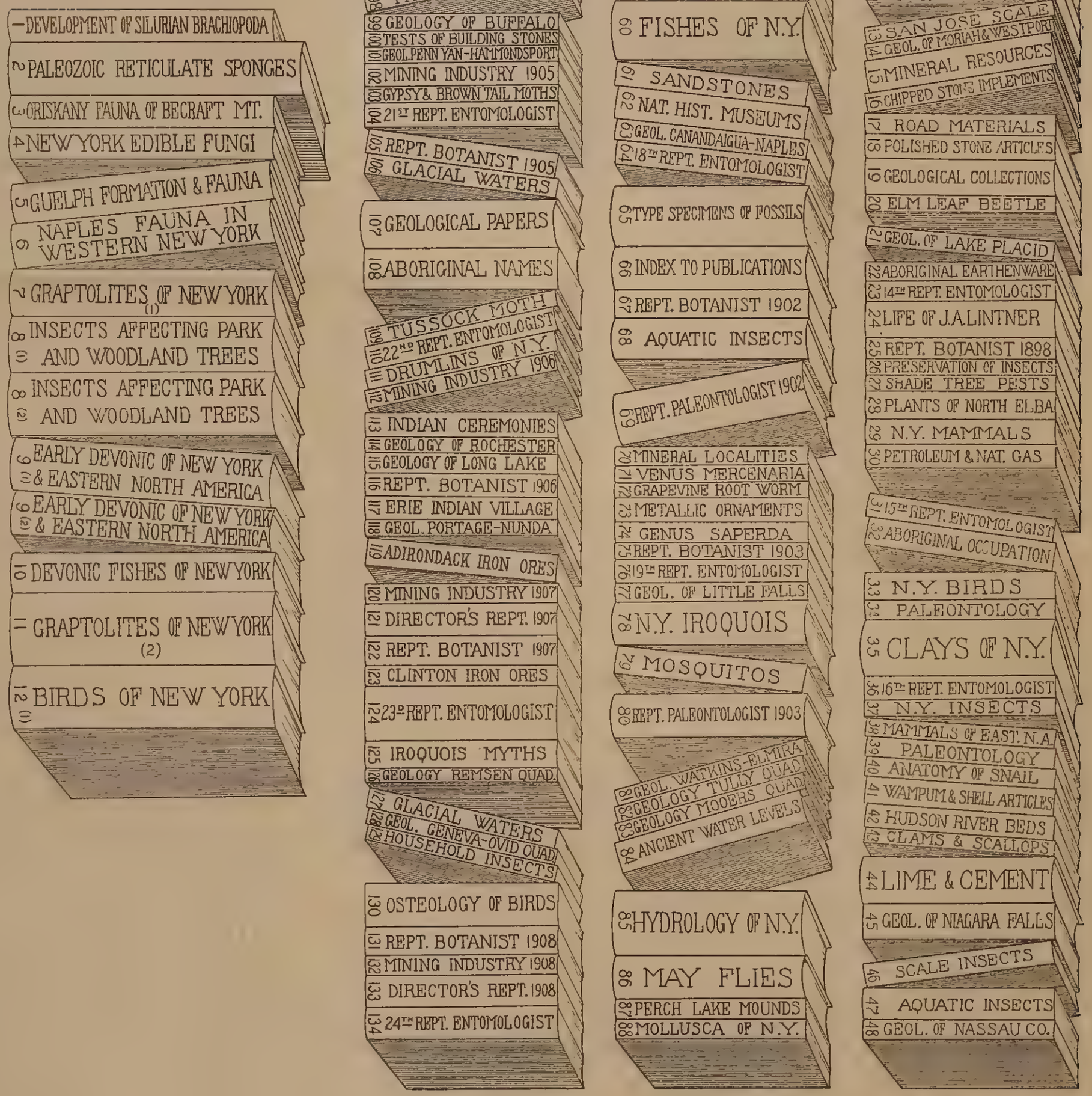


Bulletins and memoirs.

1892


1 UNIONIDAE
2 BOTANY
3 BUILDING STONE
4 N.Y. MINERALS
5 WHITE GRUB
6 CUT WORMS
7 IRON MINES
8 BOLETI OF U.S.
9 UNIONIDAE
10 BUILDING STONE
11 SALT & GYPSUM
12 CLAY
13 SAN JOSE SCALE
14 GEOL. OF MORIAH & WESTPORT
15 MINERAL RESOURCES
16 CHIPPED STONE IMPLEMENTS
17 ROAD MATERIALS
18 POLISHED STONE ARTICLES
19 GEOLOGICAL COLLECTIONS
20 ELM LEAF BEETLE
21 GEOL. OF LAKE PLACID
22 ABORIGINAL EARTHENWARE
23 14TH REPT. ENTOMOLOGIST
24 LIFE OF J.A.LINTNER
25 REPT. BOTANIST 1898
26 PRESERVATION OF INSECTS
27 SHADE TREE PESTS
28 PLANTS OF NORTH ELBA
29 N.Y. MAMMALS
30 PETROLEUM & NAT. GAS
31 15TH REPT. ENTOMOLOGIST
32 ABORIGINAL OCCUPATION
33 N.Y. BIRDS
34 PALEONTOLOGY
35 CLAYS OF N.Y.
36 16TH REPT. ENTOMOLOGIST
37 N.Y. INSECTS
38 MAMMALS OF EAST. N.A.
39 PALEONTOLOGY
40 ANATOMY OF SNAIL
41 WAMPUM & SHELL ARTICLES
42 HUDSON RIVER BEDS
43 CLAMS & SCALLOPS
44 LIME & CEMENT
45 GEOL. OF NIAGARA FALLS
46 SCALE INSECTS
47 AQUATIC INSECTS
48 GEOL. OF NASSAU CO.
49 PALEONTOLOGY
50 HORN & BONE ARTICLES
51 REPTILES & BATRACHIANS
52 REPT. PALEONTOLOGIST 1901
53 17TH REPT. ENTOMOLOGIST
54 REPT. BOTANIST 1901
55 METALLIC IMPLEMENTS
56 STATE GEOLOGIC MAP
57 ELM LEAF BEETLE
58 MINERALOGIC COLLECTIONS
59 GRAPEVINE ROOT WORM
60 FISHES OF N.Y.
61 SANDSTONES
62 NAT. HIST. MUSEUMS
63 GEOL. CANANDAIGUA-NAPLES
64 18TH REPT. ENTOMOLOGIST
65 TYPE SPECIMENS OF FOSSILS
66 INDEX TO PUBLICATIONS
67 REPT. BOTANIST 1902
68 AQUATIC INSECTS
69 REPT. PALEONTOLOGIST 1902
70 MINERAL LOCALITIES
71 VENUS MERCENARIA
72 GRAPEVINE ROOT WORM
73 METALLIC ORNAMENTS
74 GENUS SAPERDA
75 REPT. BOTANIST 1903
76 19TH REPT. ENTOMOLOGIST
77 GEOL. OF LITTLE FALLS
78 N.Y. IROQUOIS
79 MOSQUITOS
80 REPT. PALEONTOLOGIST 1903
81 GEOL. WATKINS-ELMIRA
82 GEOLOGY TULLY QUAD.
83 GEOLOGY MOORES QUAD.
84 ANCIENT WATER LEVELS
85 HYDROLOGY OF N.Y.
86 MAY FLIES
87 PERCH LAKE MOUNDS
88 MOLLUSCA OF N.Y.
89 ABORIGINAL USE OF WOOD
90 SILURIAN CEPHALOPODS
91 HIGHER CRUSTACEA
92 GEOLOGY OF SCHOHARIE
93 MINING INDUSTRY 1904
94 REPT. BOTANIST 1904
95 GEOLOGY OF ADIRONDACKS
96 GEOLOGY PARADOX LAKE
97 20TH REPT. ENTOMOLOGIST
98 MINERALOGY
99 GEOLOGY OF BUFFALO
100 TESTS OF BUILDING STONES
101 GEOL. PENN YAN-HAMMONDSPORT
102 MINING INDUSTRY 1905
103 GYPSY & BROWN TAIL MOTHS
104 21ST REPT. ENTOMOLOGIST
105 REPT. BOTANIST 1905
106 GLACIAL WATERS
107 GEOLOGICAL PAPERS
108 ABORIGINAL NAMES
109 TUSSOCK MOTH
110 22ND REPT. ENTOMOLOGIST
111 DRUMLINS OF N.Y.
112 MINING INDUSTRY 1906
113 INDIAN CEREMONIES
114 GEOLOGY OF ROCHESTER
115 GEOLOGY OF LONG LAKE
116 REPT. BOTANIST 1906
117 ERIE INDIAN VILLAGE
118 GEOL. PORTAGE-NUNDA
119 ADIRONDACK IRON ORES
120 MINING INDUSTRY 1907
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122 REPT. BOTANIST 1907
123 CLINTON IRON ORES
124 23D REPT. ENTOMOLOGIST
125 IROQUOIS MYTHS
126 GEOLOGY REMSEN QUAD.
127 GLACIAL WATERS
128 GEOL. GENEVA-OVID QUAD.
129 HOUSEHOLD INSECTS
130 OSTEOLOGY OF BIRDS
131 REPT. BOTANIST 1908
132 MINING INDUSTRY 1908
133 DIRECTOR'S REPT. 1908
134 24TH REPT. ENTOMOLOGIST
1 DEVELOPMENT OF SILURIAN BRACHIOPODA
2 PALEOZOIC RETICULATE SPONGES
3 ORISKANY FAUNA OF BECRAFT MT.
4 NEW YORK EDIBLE FUNGI
5 GUELPH FORMATION & FAUNA
6 NAPLES FAUNA IN WESTERN NEW YORK
7 GRAPTOLITES OF NEW YORK (1)
8 (1) INSECTS AFFECTING PARK AND WOODLAND TREES
8 (2) INSECTS AFFECTING PARK AND WOODLAND TREES
9 (1) EARLY DEVONIC OF NEW YORK & EASTERN NORTH AMERICA
9 (2) EARLY DEVONIC OF NEW YORK & EASTERN NORTH AMERICA
10 DEVONIC FISHES OF NEW YORK
11 GRAPTOLITES OF NEW YORK (2)
12 (1) BIRDS OF NEW YORK

Bulletins and memoirs. New York State Museum
1892–1909

4 No. 127 Glacial Waters in Central New York. By H. L. Fairchild. 64p. 27pl. 15 maps.

Contents:

Introduction
General description; preliminary outline
Detailed description
Batavia to Genesee valley
Genesee valley to Irondequoit valley
Irondequoit valley to the Cayuga depression
Cayuga depression: Clyde channels
Jordan-Skaneateles meridian to Syracuse
Marcellus channels: Lake Warren escape
Birth of Niagara Falls and Lake Erie
Onondaga valley to Limestone valley
Limestone valley to Chittenango valley
Chittenango valley to Oneida valley
Deltas
Principles in delta construction
Description
Theoretic succession: summary
Oscillations of the ice front: Warren waters
Warren outflow
Lake Dana
Theoretic lake succession
Description of the maps of glacial lake succession
Summary of the glacial drainage history
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5 No. 132 The Mining and Quarry Industry of New York State. By D. H. Newland. 98p.

Contents:

Preface
Introduction
Mineral Production in New York
Cement
Clay
Production of clay materials
Manufacture of building brick
Other clay materials
Pottery
Crude clay
Emery
Feldspar
Garnet
Graphite
Gypsum
Iron ore
Millstones
Mineral paint
Mineral waters
Natural gas
Peat
Petroleum
Pyrite
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Sand and gravel. Henry Leighton
Sand-lime brick
Slate
Stone. Henry Leighton
Production of stone
Granite
Limestone
Marble
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Paleontology

6 No. 128 Geology of the Geneva-Ovid Quadrangles. By D. Dana Luther. 44p. map.

Contents:

Stratigraphy
Siluric
Camillus shale
Bertie waterlime
Cobleskill waterlime
Rondout waterlime
Manlius limestone
Devonic
Oriskany sandstone
Onondaga limestone
Marcellus shale
Cardiff shale
Skaneateles shale
Ludlowville shale
Tichenor limestone
Moscow shale
Tully limestone
Genesee shale
Genundewa limestone horizon
West River shale
Cashaqua shale
Rhinestreet shale
Hatch shale and flags
Grimes sandstone
West Hill (Gardeau) flags and shale
High Point sandstone
Prattsburg sandstone — Wiscoy shale, Chemung sandstone
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Entomology

7 No. 129 Control of Household Insects. By Ephraim Porter Felt. 48p.

Contents:

Introduction
Disease carriers
Typhoid or house fly
Fruit flies
Malarial mosquito
Yellow fever mosquito
Annoying forms
Cluster fly
Wasps and hornets
House or rain barrel mosquito
Salt marsh mosquito
House fleas
Bedbug
Bedbug hunter
House centipede
Fabric pests
Clothes moths
Carpet beetles
Silver fish, bristle tail or fish moth
Book louse
White ants
Crickets
Food pests
House ants
Cockroaches
Larder beetle
Cheese skipper
Cereal and seed pests
Fumigation with hydrocyanic acid gas
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8 No. 134 Report of the State Entomologist for the fiscal year ending September 30, 1908. 208p. 17pl.

Contents:

Introduction
Injurious insects
Poplar sawfly
Grape blossom midge
Gladioli aphid
Green cockroach
Typhoid or house fly and disease
Notes for the year
Fruit tree insects
Small fruit insects
Shade tree insects
Miscellaneous
Publications of the Entomologist
Additions to collections
Appendix A: Studies of Aquatic Insects. J. G. NEEDHAM
Appendix B: Catalogue of the Described Scolytidae of America, north of Mexico. J. M. SWAINE
Explanation of plates
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Botany

9 No. 131 Report of the State Botanist for the fiscal year ending September 30, 1908. 202p. 4pl.

Contents:

Introduction
Plants added to the herbarium
Contributors and their contributions
Species not before reported
Remarks and observations
New extralimital species of fungi
New York species of Lentinus
New York species of Entoloma
List of species and varieties of fungi described by C. H. Peck
Explanation of plates
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Zoology

10 No. 130 Osteology of Birds. By R. W. Shufeldt. 382p. 26pl.

Contents:

Accipitres
Preface
Introduction
Cathartidae
Falconidae
Osteological characters synoptically arranged
Relationships
Addenda
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Gallinae
Gallus bankiva
Analytical summary
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Appendicular skeleton
Anserinae
Trunk skeleton of the Anserinae
Cygninae
Notes on fossil Anseres
Remarks on the classification of the North American Anseres
Affinities
Explanation of plates
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Archeology

11 No. 125 Myths and Legends of the New York State Iroquois. By Harriet Maxwell Converse. Edited and annotated by Arthur Caswell Parker. 196p. 11pl.

Contents:

Prefatory note
Introduction
Biography of Harriet Maxwell Converse
Pt 1 Iroquois Myths and Legends. HARRIET MAXWELL CONVERSE
Pt 2 Myths and Legends. Harriet Maxwell Converse (Revised from rough drafts)
Pt 3 Miscellaneous papers. HARRIET MAXWELL CONVERSE
Neh Ho-noh-tci-noh-gah, the Guardians of the Little Waters, a Seneca Medicine Society. A. C. PARKER
Appendix A. Origin of Good and Evil.
Appendix B. The Stone Giants
Appendix C. The De-o-ha-ko
Appendix D. The Legendary Origin of Wampum
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14 Birds of New York, volume 1
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16 Geology of the Port Leyden Quadrangle
17 Geology of the Thousand Island Region
18 Geology of the Auburn-Genoa Quadrangles
19 Geology of the Elizabethtown and Port Henry Quadrangles

Entomology

20 Report of the State Entomologist for the fiscal year ending September 30, 1909

Botany

21 Report of the State Botanist for the fiscal year ending September 30, 1909

VIII

STAFF OF THE SCIENCE DIVISION AND STATE MUSEUM

The members of the staff, permanent and temporary, of this division as at present constituted are:

ADMINISTRATION

John M. Clarke, *Director*
Jacob Van Deloo, *Director's clerk*

GEOLOGY AND PALEONTOLOGY

John M. Clarke, *State Geologist and Paleontologist*
David H. Newland, *Assistant State Geologist*
Rudolf Ruedemann Ph.D., *Assistant State Paleontologist*
C. A. Hartnagel B.S. M.A., *Assistant in Geology*
Henry Leighton, *Assistant in Economic Geology*
D. Dana Luther, *Field Geologist*
Herbert P. Whitlock C.E., *Mineralogist*
George S. Barkentin, *Draftsman*
Joseph Morje, *First clerk*
H. C. Wardell, *Preparator*
Paul E. Reynolds, *Stenographer*
Martin Sheehy, *Machinist*
Joseph Bylancik, *Page*

Temporary assistants

Areal geology

Prof. H. P. Cushing, Adelbert College
Prof. J. F. Kemp, Columbia University
Dr C. P. Berkey, Columbia University
Prof. C. E. Gordon, Massachusetts Agricultural College
G. H. Hudson, Plattsburg State Normal School
Prof. W. J. Miller, Hamilton College
Prof. H. O. Whitnall, Colgate University
Burton W. Clark, Washington, D. C.

Geographic geology

Prof. Herman L. Fairchild, Rochester University

Paleontology

Edwin Kirk, Columbia University

BOTANY

Charles H. Peck M.A., *State Botanist*
Stewart H. Burnham, *Assistant,* Glens Falls

ENTOMOLOGY

Ephraim P. Felt B.S. D.Sc., *State Entomologist*
D. B. Young, *Assistant State Entomologist*
Fanny T. Hartman, *Assistant*
Anna M. Tolhurst, *Stenographer*
J. Shafer Bartlett, *Clerk*

ZOOLOGY

Frank H. Ward, *Zoologist*
Alfred J. Klein, *Taxidermist*

Temporary assistants

E. Howard Eaton, Canandaigua
Dr H. A. Pilsbury, Philadelphia
Prof. Philip F. Schneider, Syracuse

ARCHEOLOGY

Arthur C. Parker, *Archeologist*

Temporary assistant

E. R. Burmaster, Irving

IX

ACCESSIONS

ECONOMIC GEOLOGY

Collection

Assistant in Economic Geology

Gypsum,	Akron	12
"	Camillus	10
"	Clockville	2
"	Garbutt	26
"	Jamesville	4
"	Lyndon	6
"	Martisco	4
"	Oakfield	4
"	Phelps	2
"	Victor	3
"	Wheatland	1

Gypsum mill products..... 15
Limestone associated with gypsum..... 4

Clarke, John M.
Gypsum, Magdalen Islands, Quebec..... 100

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PALEONTOLOGY

Donation

His excellency Governor and Mrs Allardyce. Falkland Islands

The following fossils and minerals from Falkland Islands
Casts of trilobites..... 4
Miscellaneous fossils..... 16
Minerals..... 5

Mansuy, H. Hanoi (Tonkin) Indo-China
Spirifer tonkinensis. Lower Devonic from Ban Lan, French China.. 1
Spirifer..... 1

Schuchert, *Prof.* **Charles**
Graptolites from Point Levis, P. Q., Canada..... 13
Graptolites from Anticosti island, P. Q., Canada..... 7

von Koenen, *Prof. Dr* **A.** Göttingen, Germany. Devonic fossils from Martenberg and Enkeberg, Germany

From Martenberg, Germany
Agoniatites inconstans..... 1
A. inconstans *var.* expansus *Van*..... 1
A. inconstans *var.* nodosus..... 1
A. inconstans *var.* obliquus *Whitb*..... 1
Anarcestes nuculiformis *Holz*..... 3
Gephyroceras calculiforme..... 1
G. intumescens..... 1
Kophinoceras alatum *Holz*..... 1
Maenoceras terebratum..... 6
Stringocephalus burtini..... 2
Tornoceras simplex..... 1

From Enkeberg
Aganides sulcatus *Münster*..... 2
Cheiloceras circumplexum *Sand*..... 1
C. verneuili *Sand*..... 2
Poterioceras subfusiforme *Wed*..... 2
Prolobites delphinus *Sand*..... 1
P. delphinus *var.* atava *Frech*..... 1
P. delphinus *var.* ellipticum *Wed*..... 1
Sporadoceras angustisellatum *Wed*..... 3
S. münsteri *von Buch*..... 9
Tornoceras rotundodorsatum *Wed*..... 3
T. sandbergeri..... 3

Wilson, John D. Syracuse, N. Y.
Thoracoceras wilsoni *Clarke*..... 1

Purchase

Wilson, John D. Syracuse, N. Y.

Tully limestone	
Brachiopods	12
Gastropods	1
Cephalopods	1
Hamilton	
Corals	6
Brachiopods	16
Gastropods	27
Lamellibranchs	38
Cephalopods	2
Trilobites	10
Agoniatite limestone	
Brachiopods	10
Cephalopods	57
Onondaga limestone	
Gastropods	27
Cephalopods	3
Trilobites	1
Cambric	
Trilobites	2
Total	213

Collection

Assistant State Paleontologist. Graptolites from Lower Siluric shales of Saratoga county..... 216

Clarke, John M.

Carboniferous fossils, Magdalen Islands, Quebec.....bbls. 4
Geological specimens, Magdalen Islands, Quebec..... 50

Cushing, *Prof.* **H. P., Ruedemann, R. & Miller,** *Prof.* **W. J.** Fossils, mostly trilobites, from the Saratogan (Hoyt's quarry), Saratoga co. 400
Fossils from Beekmantown limestone of Mohawk valley..... 31
Fossils from Trenton limestone, Saratoga co..... 32

Hartnagel, C. A. Eurypterids from Bertie waterlime, Herkimer co. 30

Hartnagel, C. A. & Van Deloo, Jacob. Eurypterids from Bertie waterlime, Herkimer co..... 500

Luther, D. D. Crinoids from Grimes sandstone near Naples..... 20
Crinoids and starfishes from Grimes sandstone, Italy Hollow gully, near Naples, N. Y.....boxes 5
Crinoids from Hamilton formation near West Alden, Erie co..... 8

Wardell, H. C. Graptolites from Rural Cemetery, Albany..... 25
Oriskany fossils from Glenerie, Ulster co..... 500

MINERALOGY

Donation

Kelley, F. W. Albany
Calcite in limestone, Howe Cave 2

Magill, C. M. Albany
Geode containing goethite, Keokuk, Iowa 1

Ross, J. McCormick, S. C.
Psilomelane and barite replacing asbestos, McCormick, S. C 1
Serpentine (asbestos), McCormack, S. C 1
Psilomelane, McCormick, S. C 12
Barite on psilomelane 8

Moore, E. L. Port Byron, N. Y.
Vesuvianite and epidote, Fassathal, Tyrol 1
Fluorite, Cumberland, Eng 1
Pyrite and chalcopyrite, Colorado (?) 1
Tourmalin, Paris, Me 2

Snyder, W. S. Watervliet
Calcite and sphalerite, Arizona 5

Exchange

Canfield, F. A. Dover, N. J.
Pyrite on calcite, Bergen Hill, N. J 1
Stilbite on datolite, Bergen Hill, N. J 1
Apophyllite, analcite and atolite, Bergen Hill, N. J 1
Natrolite and apophyllite, Bergen Hill, N. J 1
Natrolite and datolite, Bergen Hill, N. J 1

Manchester, J. G. New York
Calcite and datolite, Bergen Hill, N. J 10
Calcite and apophyllite, Bergen Hill, N. J 4
Apophyllite and datolite, Bergen Hill, N. J 3
Apophyllite and natrolite, Bergen Hill, N. J 2
Apophyllite and analcite, Bergen Hill, N. J 3
Apophyllite and calcite, Bergen Hill, N. J 1
Apophyllite, Bergen Hill, N. J 9
Apophyllite on stilbite, Bergen Hill, N. J 1
Analcite on calcite, Bergen Hill, N. J 1
Natrolite, Bergen Hill, N. J 3
Datolite, Bergen Hill, N. J 5
Stilbite on datolite, Bergen Hill, N. J 1
Chalcopyrite on datolite, Bergen Hill, N. J 1
Chalcopyrite on calcite, Bergen Hill, N. J 1
Sphalerite on stilbite (large), Bergen Hill, N. J 1
Sphalerite and datolite, Bergen Hill, N. J 1
Calcite, Bergen Hill, N. J 1

Foote Mineral Co. Philadelphia, Pa.
Pyrite, Bingham, Utah 4
Pyrite and tetrahedrite, Bingham, Utah 1
Tetrahedrite, Bingham, Utah 1

Pentlandite, Sudbury, Ontario..... 1
Sphalerite, Kokomo, Col..... 1
Covellite, Summitville, Col..... 1
Opal (opalized wood), Clover Creek, Idaho..... 1
Wollastonite, Blount Mt, Tex..... 1
Natrochalcite, Chuquicamata, Chili..... 1
Kröhnkite, Chuquicamata, Chili..... 1
Brochantite, Chuquicamata, Chili..... 1
Orthoclase (valencianite), Guanajuato, Mex..... 1
Quartz (twin crystal), Guanajuato, Mex..... 1
Nadorite, Djebel-Nador, Algeria..... 1
Chabazite, Melbourne, Victoria..... 1
Newberryite, near Ballarat, Victoria..... 48
Amblygonite, Port Darwin, S. Aust..... 1
Anglesite on cerussite, Broken Hill, N. S. W..... 1
Cabrerite, Laurium, Greece..... 1

Peck, H. C. Albany.

Zoisite, Chester, Mass..... 1
Octahedrite, Somerville, Mass..... 1

Purchase

Comptoir Mineralogique Suisse, Geneva, Switz.

Phenacite, San Miguel do Piracicava, Minas Geraes, Brazil..... 1

Hodge, R. S. Antwerp

Millerite on hematite, Antwerp..... 60
Hematite (botryoidal), Antwerp..... 6
Hematite (specular) on quartz, Antwerp..... 11
Hematite (stalactitic), Antwerp..... 5
Chalcopyrite on quartz, Antwerp..... 2
Pyrite and calcite, Antwerp..... 1
Pyrite and ankerite, Antwerp..... 2
Calcite on hematite, Antwerp..... 9
Calcite and dolomite, Antwerp..... 1
Calcite on chalcodite (large), Antwerp..... 1
Dolomite and ankerite, Antwerp..... 5
Dolomite (stalactitic), Antwerp..... 1
Ankerite on hematite, Antwerp..... 9
Ankerite (stalactitic), Antwerp..... 8
Ankerite on quartz, Antwerp..... 10
Quartz (drusy stalactite), Antwerp..... 2
Quartz on hematite, Antwerp..... 20
Chalcodite on stalactitic quartz, Antwerp..... 5
Chalcodite on quartz, Antwerp..... 3
Chalcodite on calcite, Antwerp..... 3
Chalcodite on hematite, Antwerp..... 6
Chalcodite and ankerite, Antwerp..... 6
Goethite on ankerite and quartz, Antwerp..... 1
Fluorite, Macomb..... 3
Quartz in matrix, Little Falls..... 1

Tourmalin, Gouverneur	1
Quartz, Ellenville	1
Fluorite, Cumberland, Eng	5
Siderite on fluorite, Cumberland, Eng	2
Pyrite, England	2
Barite, Cumberland, Eng	1
Apatite, Norway	1
Psilomelane, Sevilla, Spain	1
Sulfur and calcite, Girgenti, Sicily	1
Cryolite, Greenland	1
Apophyllite, Guanajuato, Mex	1
Apatite, Renfrew co., Ontario, Can	1
Stilbite, Partridge Island, N. S	3
Heulandite, Nova Scotia	2
Chabazite, Nova Scotia	1
Hematite, Lake Superior	1
Albite (cleavelandite), Auburn, Me	1
Lepidolite, Auburn, Me	1
Vesuvianite in epidote, Minot, Me	1
Spodumene, Peru, Me	1
Cancrinite, Litchfield, Me	1
Zircon, Litchfield, Me	1
Orthoclase, Maine	1
Garnet, Russell, Mass	1
Margarite, Chester, Mass	1
Andalusite (chiastolite), Lancaster, Mass	1
Cyanite, Norwich, Conn	1
Diabantite, Farmington, Conn	1
Pyrolusite and limonite, Ore Hill, Conn	1
Tourmalin, Haddam, Conn	1
Wernerite, Connecticut	1
Willemite, Franklin, N. J	1
Franklinite, Franklin, N. J	1
Pyrite, French Creek, Pa	8
Chalcopyrite, French Creek, Pa	2
Cyanite, Delaware co., Pa	1
Garnet, Delaware co., Pa	1
Laumontite, Frankford, Pa	1
Pyromorphite, Phoenix, Pa	1
Limonite, Ebbville, Md	1
Pyrophyllite, Chesterfield co., S. C	1
Talc (steatite), Mantahala, N. C	1
Rutile, Graves Mt, Ga	1
Quartz, Crystal Mt, Ark	1
Quartz, Hot Springs, Ark	1
Wavellite, Garland co., Ark	1
Sphalerite, Joplin, Mo	1
Marcasite on sphalerite, Joplin Mo	1
Gypsum, Mahoning co., O	1
Quartz (geode), Warsaw, Ill	9

Microcline (amazon stone), Pikes Peak, Col	2
Halite, Lincoln co., Nev	1
Proustite and stephanite, Lander co., Nev	1
Wulfenite, Nevada	1
Galena, Utah	1
Cinnabar, New India, Col	1
Gold in quartz, California	1
Tetrahedrite, California	1
Quartz (geyserite), Yellowstone Park, Wyo	1
Wulfenite, Yuma co., Ariz	1
Azurite and malachite, Bisbee, Ariz	1
Malachite, Bisbee, Ariz	1
Chrysocolla, Loc. ?	1
Calamine, Loc. ?	1
Beryl (large), Loc. ?	1
Quartz & chalcedony, Loc. ?	1
Quartz (large), Loc. ?	2
Vivianite, Loc. ?	1

Collection

Assistant in Economic Geology

Gypsum, Garbutt	15

Mineralogist

Serpentine pseudomorph after garnet (loose crystals), Saratoga	15
Serpentine pseudomorph after garnet in matrix (large), Saratoga	8
Serpentine pseudomorph after garnet in matrix (small), Saratoga	10
Garnet in gneiss, Saratoga	4
	488

BOTANY

Plants added to the herbarium

New to the herbarium

Ascochyta solani-nigri *Diedicke*
Belonidium glyceriae *Pk.*
Biatora cupreo-rosella (*Nyl.*) *Tuck.*
Bidens tenuisecta *Gray*
Boletus viridarius *Frost*
Carduus crispus *L.*
Chaenactis stevioides *H. & A.*
Ciboria luteo-virescens *R. & D.*
Clitocybe candida *Bres.*
Cortinarius subsalmoneus *Kauff.*
Crataegus brevipes *Pk.*
C. efferata *S.*
C. letchworthiana *S.*
Diplocladium penicilloides *Sacc.*
Diplodia cercidis *E. & E.*
D. hamamelidis *Fairm.*
D. tamariscina *Sacc.*
Dothiorella divergens *Pk*
Epipactis tesselata (*Lodd.*) *Eaton*
Fenestella amorpha *E. & E.*
Hypholoma boughtoni *Pk.*
H. rigidipes *Pk.*
Leontodon nudicaulis (*L.*) *Banks*
Ligusticum scoticum *L.*
Lophiotrema hysterioides *E. & E.*
L. littorale *Speg.*
Marasmius alienus *Pk.*
Melanopsamma confertissima (*Plowr.*)
Microcera coccophila *Desm.*

Midotis irregularis (*Schw.*) *Cke.*
Monolepis nuttalliana (*R. & S.*)
Morchella crispa *Karst.*
M. rimosipes *DC.*
Nardia crenulata (*Sw.*) *Lindb.*
N. hyalina (*Lyell*) *Carr.*
Peridermium strobi *Kleb.*
Pezizella lanc.-paraphysata *Rehm*
Phaeopezia fuscocarpa (*E. & H.*)
Pholiota aurivella *Batsch*
Phomopsis stewartii *Pk.*
Picris echinoides *L.*
Polyporus giganteus (*Pers.*) *Fr.*
Psilocybe nigrella *Pk.*
Puccinia epiphylla (*L.*) *Wettst.*
Ribes triste albinervium (*Mx.*)
Rubia tinctorium *L.*
Rumex pallidus *Bigel.*
Schwalbea americana *L.*
Septoria sedicola *Pk.*
Solidago aspera *Ait.*
Sparganium diversifolium *Graebn.*
Stachys sieboldii *Miq.*
Stephanoma strigosum *Wallr.*
Trametes merisma *Pk.*
Verticillium rexianum *Sacc.*
Volvaria volvacea (*Bull.*) *Fr.*

ENTOMOLOGY

Donation

Hymenoptera

Cockerell, T. D. A. Boulder, Col. Sphecodes fragariae Ckll., S. sophiae Ckll. var. Halictus scrophularia Ckll., Augochlora neglectula Ckll., Andrena prunorum gilletti Ckll., Panarginus cressoniellus Ckll., February 16

Rohwer, S. A. Boulder, Col. Steniolia obliqua Say, Trypoxylon frigidum Sm., Thyreopus latipes Sm. Andrena geranii Rob., A. porterae Ckll., A. prunorum Ckll., Nomada collinsiana Ckll., Osmia fulgida Cress., Dianthidium parvum Cress., Megachile pugnata Say, Ceratina neomexicana Ckll., Melissodes obliqua Say, M. agilis Cress., Anthophora simillima Cress., November 12

Batly, *Miss* **M. A.** Schaghticoke. Xylocopa virginica Dru., large carpenter bee, adult, June 28

Doubleday, Page & Co. New York. Agapostemum viridula Fabr., solitary digger bee, adult, from Rutland, Vt., July 9

Patterson, O. D. Richburg. Thalessa atrata Fabr., black long sting, adult, June 24

Hasbrouck, *Miss* **L. M.** Ogdensburg. Rhodites rosae Linn., rose bedegar, gall on rose, July 10

Frost, H. L. & Co. White Plains. Andricus clavula Bass., oak tip gall on white oak, October 23

Goldmark, *Miss* **Josephine.** St Huberts. Lophyrus lecontei Fitch, pine sawfly, larvae on pine, July 31

Huested, Percy L. Rochester. Emphytus cinctus Linn., coiled rose slug, larva on rose, January 30

Thomson, J. A. Rochester. Amauronematus azaleae Marlt., larvae on azalea, June 8

Livingston, J. H. Tivoli. Kaliosysphinga ulmi Sund., elm leaf miner, larvae on elm, June 7

Thomson, J. A. Rochester. Same as preceding, June 17

Thompson, *Miss* **Rhoda.** Ballston Spa. Lygaeonematus erichsonii Hart., larch sawfly, larvae on larch, June 28

Hoover, D. D. Syracuse. Tremex columba Linn., pigeon Tremex, adult, September 13

Closson, R. Addison. Same as preceding, adult on maple, September 22

Coleoptera

Forest, Fish & Game Commission. Hylesinus aculeatus Say, ash bark beetle, adults, eggs and larvae on ash, from Cornwall, May 18

Levison, J. J. Brooklyn. Eccoptogaster quadrispinosus Say, hickory bark borer, larvae on hickory, October 28

Hoover, D. D. Syracuse. Eccoptogaster rugulosus Ratz., hickory bark borer, adult and larvae on hickory, September 17

Roach, Paul. Quaker Street. Pomphopoea sayi Lec., Say's blister beetle, adults on rose, June 28

Niles, T. F. State Department of Agriculture. Epicauta ? punctiollis Mann., blister beetle, adults, from Chatham, July 24

Norris, E. B. Sodus. Disonycha pennsylvanica Ill., adult on apple trees, March 31

Zabriskie, George. Nissequogue, St James, L. I. Galerucella luteola Mull., elm leaf beetle, larvae on elm, July 12

Forest, Fish & Game Commission. Same as preceding, from Greenport, July 8

Fish, J. H. Greenport. Same as preceding, July 14

Delafield, *Mrs* **Albert.** Greenport. Larvae and pupae of preceding, August 18

McKensie, P. B. Northport. Same as preceding, July 23

VanClefe, John O. Oakdale. Same as preceding, July 26

White, E. M. Sag Harbor. Same as preceding, August 5

Simpson, C. L. Amsterdam. Same as preceding, August 24

Miller, *Mrs* **W. S.** Boonville. Trichius affinis Gory, adult, July 15

Chatfield, Frederick. Troy. Euphoria inda Linn., flower beetle, adults, September 21

Schaible, G. C. Brooklyn. Macrodactylus subspinosus Fabr., rose beetle, adults, June 19

Lindquist, F. Brooklyn. Same as preceding, June 21

Blunt, *Miss* **Eliza S.** New Russia. Chalcophora liberta Germ., smaller flat-headed pine borer, adult, June 3

Country Gentleman. Phengodes plumosa Oliv., larva, from Ridgefield, Conn., August 9

Nash, C. W. Toronto, Can. Asaphes decoloratus Say, larvae killed by a fungus, Cordyceps aciculariis Rav. (C. carolinensis B. & R., Ravenel's *Exsiccati*) November 27

Patterson, *Mrs* **J. D.** Pattersonville. Alaus oculatus Linn., owl beetle or eyed elater, adult, June 23

Hepworth, J. A. Marlborough. Silvanus surinamensis Linn., saw-toothed grain beetle, adult in flour, April 20

Winchester, Milo F. South Amenia. Anatis ocellata Linn., larva, pupa and adult on apple, July 1

Ferris, S. B. Upper Saranac. Nomius pygmaeus Dej., August 21

Diptera

Brisbin, C. E. Schuylerville. Rhagoletis pomonella Walsh, many adults on apple; R. suavis Loew, adult on apple, September 10

Baldwin, L. F. Albany. Bombyliomyia abrupta Wied., adult, August 25

Clarke, *Miss* **Cora H.** Numerous Cecidomyiid galls were received from Boston and Magnolia, Mass. and a number of new species reared from the material contributed. [*See* Econ. Ent. Jour. 1909, 2:286–93]

Alexander, C. P. Johnstown. A number of Cecidomyiids were received during the season.

Dimmock *Dr* **George.** Springfield, Mass. Rhopalomyia hirtipes O. S., numerous subterranean galls on Solidago, September 2

Packard, Winthrop. Canton, Mass. Sackenomyia packardi Felt, larvae in willow shoots, April 15

Webster, F. M. Washington, D. C. Lasioptera tripsaci Felt, adults reared from Tripsacum dactyloides, from Texas

Nash, George V. Bronx Park, New York. Cecidomyia opuntiae Felt, reared from Opuntia leaves

A number of other gall midges have been received from various parties and will be duly acknowledged in subsequent descriptions or discussions of the species.

Lepidoptera

Call, *Miss* **Emma S.** Northport. Sphecodina abbotii Swain, Abbot's sphinx, larvae on woodbine, July 30

Openhym, *Mrs* **A.** St Huberts. Same as preceding, August 12

Bell & Smith Nursery Seed Co. Castleton. Deilephila lineata Fabr., white lined sphinx, moth, September 11

Shults, Ezra. Fort Plain. Sphinx drupiferarum Sm. & Abb., plum sphinx, adult, June 7

Fitch, H. H. West Winfield. Sphinx chersis Hubn., ash sphinx, adult, July 26

Delafield, *Mrs* **Albert.** Greenport. Halisidota caryae Harr. on elm, August 18

Slade, George P. New York city. Heliophila unipuncta Haw., army worm, larvae, from Oakdale, June 17

Frispell, *Dr* **C. W.** Shelter Island Heights. Heliothis armiger Hubn., corn worm, larvae on corn, October 19

Baxter, Jarvis W. Adams Corners. Melalopha inclusa Hubn., poplar tentmaker, larvae on poplar, August 2

Dillingham, E. Ogdensburg. Notolophus antiqua Linn., dark or rusty tussock moth, larvae, June 29

Burbank, Charles. LaGrangeville. Tolype velleda Stoll., larch lappet, larva, July 23

Emans, Ernest. LaGrangeville. Paleacrita vernata Peck, spring canker worm, larvae on apple trees, May 31

Floyd, Augustus. Moriches. Alsophila pometaria Harr., fall canker worm, adults, November 30 and December 2

Jackson, *Mrs* A. M. A. Warner. Acrobasis larvae on hickory, June 12

Huested, P. L. Blauvelt. Archips cerasivorana Fitch, ugly nest cherry worm, nest, July 17

Bailey, G. A. Syracuse. Tortrix fumiferana Clem., spruce bud worm, adults, July 21

Lohrmann, Richard. Utica. Same as preceding, July 22

Fitch, F. A. Randolph. Coleophora fletcherella Fern., cigar case bearer, larvae on apple, June 16

VanClefe, John O. Oakdale. Coleophora limosipennella Dup., European elm case bearer, cases and adults, August 4

Latham, Roy. Orient Point. Antispila nyssaefoliella Clem., larvae and work on pepperidge, September 25

Corrodentia

Burnham, S. H. Vaughn. Psocus salicis? Fitch, nymph in house, November 4

Hemiptera

Cook, Paul. Troy. Enchenopa binotata Say, 2-spotted tree hopper, egg masses on bittersweet, August 25

Gillett, J. R. Kingston. Belostoma americanum Leidy, electric light bug, adult, October 26

Thomson, J. A. Rochester. Leptobyrsa explanata Heid., lace-winged bug, larvae on Rhododendron, June 8

Huested, P. L. Blauvelt. Same as preceding, adult, July 5

O'Mara, J. F. Cornwall. Aleyrodes citri Riley & Howard, white fly on orange leaf, from Florida, June 15

Livingston, J. H. Tivoli. Phyllaphis fagi Linn., woolly beech leaf aphis, adults on beech, May 15

Huested, P. L. Blauvelt. Chermes strobilobius Kalt., spruce gall aphid, galls on spruce, May 3

Ray, *Mrs* George W. Norwich. Chermes pinicorticis Fitch, pine bark aphid, adults on pine, March 30

Breithaupt, E. & W. G. Phoenicia. Same as preceding, adults and eggs on balsam, September 11

Livingston, J. H. Tivoli. Adults of preceding on pine, September 14

May, William B. Irvington. Chermes abietis Linn., spruce gall aphid, galls on spruce, March 8

Pettis, C. R. Lake Clear Junction. Same as preceding, August 14

Witherbee, F. S. Port Henry. Phylloxera caryaecaulis Fitch, hickory gall aphid, adults and young on hickory, June 30

Ackley, Henry. Cambridge. Pemphigus vagabundus Walsh, galls on poplar, July 30

McCulloch, C. H. Schenectady. Same as preceding, August 11.

Ackley, Henry. Cambridge. Pemphigus populi-transversus Riley, galls on poplar, July 30

Donan, W. C. LeRoy. Colopha ulmicola Fitch, cockscomb elm gall on elm, July 19

Niles, H. W. State Department of Agriculture. Schizoneura americana Riley, woolly elm leaf aphid, adults on elm, from Rye, July 6

Graves, *Mrs* **H. D.** Ausable Forks. Same as preceding, June 25

Foulk, Theodore. Flushing. Lachnus dentatus LeBaron, adult on willow, September 23

Jones, H. G. Dunkirk. Callipterus ulmifolii Monell, elm leaf aphid, badly infested leaves of elm, June 29

Thomson, J. A. Rochester. Psyllid, June 17

Menand, L. Albany. Chrysomphalus dictyospermi Morg., Morgan's scale, all stages, abundant and causing serious damage on palm, December 28

Livingston, J. H. Tivoli. Eulecanium tulipiferae Cook, tulip tree scale, adults on tulip, September 14

VanAlstyne, H. Chatham Center. Coccus hesperidum Linn., soft scale, young and adults on begonia, December 12

Dummett, Arthur. Mt Vernon. Phenacoccus acericola King, false maple scale, young on maple, November 10

Thomson, J. A. Rochester. Pulvinaria vitis Linn., cottony maple scale, adults on maple, June 21

Huested, P. L. Blauvelt. Gossyparia spuria Modeer, elm bark louse, adult on elm, from Catskill, June 21

Foley, *Miss* **Frances.** Cornwall. Aulacaspis rosae Sandbg., rose scale, eggs on blackberry, April 22

Niles, T. F. State Department of Agriculture. Aulacaspis pentagona Targ., West Indian peach scale on Prunus pseudocerasus, from New Rochelle

Gibson, Arthur. Ottawa, Can. Chionaspis pinifoliae Fitch, pine leaf scale on spruce, January 5

Foulk, Theodore. Flushing. Same as preceding, on Austrian pine, September 11

Richmond, Charles A. East Aurora. Aspidiotus forbesi John., on apple, November 6

Cunningham, Thomas. Vancouver, B. C. Aspidiotus ostreaeformis Curt. on apple, pear and plum, October 29

Burt, A. C. Owego. Aspidiotus perniciosus Comst., San José scale, adults on apple, April 10

Smith, A. J. Rexford Flats. Same as preceding, June 1

Windsor, *Mrs* **P. L.** Austin, Tex. Very kindly determined by E. P. VanDuzee, Buffalo. Draeculacephala reticulata Sign., Deltocephalus sonorus Ball, D. flavicosta Stal., D. nigrifrons Forbes, D. obtectus O. & B., D. inimicus Say, Xestocephalus pulicarius VanD., X. brunneus VanD., Eutettix strobi Fitch, E. stricta Ball, Acinopterus acuminatus VanD., Phlepsius spatulatus VanD., Athysanus exitiosus Uhler, Platymetopius near loricatus VanD., Scaphoideus consors Uhler, typical, S. immistus Say, Typhlocyba vulnerata Fitch, T. comes Say, T. sp. (near trifasciata), T. comes var. vitis Harr., T. tri-

cincta Fitch, Oliarus complectus Ball, Pissonotus delicatus VanD., P. basalis VanD., ater Van. D. ?, Liburnia pellucida Fabr. ?, L. consimilis VanD., Empoasca mali LeBaron, E. flavescens Fabr., E. sp. new, Balclutha abdominalis VanD. ?, Nysius minutus Uhler, Reuteroscopus ornatus Reut., Atomoscelis seriatus Reut. ?

Orthoptera

Appleby, Lansing. Clarksville. Oecanthus niveus DeG., snowy tree cricket, eggs on raspberry, April 3

Thompson, J. A. Syracuse. Periplaneta americana Linn., American cockroach, adult, April 10

Adams, Louis H. Canandaigua. Mantis religiosa Linn., European Mantis, egg mass, February 15

Thysanura

Jackson & Perkins. Newark. Achorutes nivicola? Fitch, very abundant on sand, April 8

Isoptera

VanDenburg, M. W. Mt Vernon. Termes flavipes Linn., white ants, adults, April 19

Exchange

Hymenoptera

Tucker, E. S. Manhattan, Kan. Trypoxylon carinifrons Fox, Polistes minor Beauv.

Coleoptera

Berosus subsignatus Lec., Psyllobora taedata Lec., Conotelus stenoides Murr., Scaptolenus lecontei Salle, Photinus benignus Lec. Lobetus abdominalis Lec.

Diptera

Beskia aelops Walk., Sturmia distincta Wied., Sarcophaga assidua Walk., S. quadrisetosa Coq., Pseudopyrellia comicina Fabr., Pachycerina clavipennis Coq.

Lepidoptera

Chlorochlamys phyllinaria Zell., Loxostege mancalis Led., Lineodes integra Zell., Crambus teterrellus Zink., C. mutabilis Clem., Saluria tetradella Zell., Pterophorus inquinatus Zell., Platynota nigrocervina Wals., Anaphora popeanella Clem.

Purchase

Kny-Scheerer Co. New York city

House fly, Musca domestica Linn. (x 30), model

Malarial mosquito, Anopheles, dissectible model of head (x 800)

House mosquito, Culex pipiens Linn., dissectible model of head (x 800)

ZOOLOGY

Donation

Mammals

Alexander, Charles P. Johnstown. Say's bat, Myotis subulatus (Say), skin 1
Baumer, J. H. Cedar Hill. Virginia deer, Odocoileus virginianus (Boddaert), fossil skull 1
Scace, William. Schenectady road. Otter, Lutra canadensis Schreber, juv. skins 2
Woodruff, E. S. Albany. Raccoon, Procyon lotor (Linn.), skull 1

Birds

Alexander, Charles P. Johnstown
White-winged crossbill, Loxia leucoptera Gmel., skins 3
Redpoll, Acanthis linaria (Linn.), skin 1
Pine siskin, Spinus pinus (Wilson), skins 2
Nashville warbler, Vermivora rubricapilla (Wils.), skin .. 1
Yellow warbler, Dendroica aestiva (Gmel.), skin 1
Black-throated blue warbler, Dendroica caerulescens (Gmel.), skin 1
Chestnut-sided warbler, Dendroica pennsylvanica (Linn.), skin 1
Pine warbler, Dendroica vigorsii (Aud.), skin 1
Mourning warbler, Oporornis philadelphia (Wils.), skin .. 1
Maryland yellowthroat, Geothlypis trichas (Linn.), skin 1
Wilson's warbler, Wilsonia pusilla (Wis.), skin 1
Canadian warbler, Wilsonia canadensis (Linn.), skin 1
Delavan, *Dr* **E. H.** Round Lake. Four-legged chicken, spec 1
Drumm, Jimmy. Albany. Canary, Carduelis canaria (Linn.), skin 1
Friend, William. New Baltimore. Turkey vulture, Cathartes aura septentrionalis (Wied.), skin 1
Forest, Fish & Game Commission. Albany. Wood duck, Aix sponsa (Linn.), skin 1
Hall, Charles. Albany
American goshawk, Astur atricapillus (Wilson), skin 1
Red-shouldered hawk, Buteo lineatus (Gmel.), skin 1
Helm, Harry. Sharon Springs. Four-legged chicken, spec 1
Klein, A. J. Albany
Water turkey, Anhinga anhinga (Linn.), skin 1
Florida cormorant, Phalacrocorax auritus floridanus (Aud.), skins 2
Red-shouldered hawk, Buteo lineatus (Gmel.), skin 1
Barred owl, Strix varia Barton, skin 1
Short-eared owl, Asio flammeus (Pontop.), skins 3
Leighton, Henry. Albany
Redpoll, Acanthis linaria (Linn.), skin 1
Pine siskin, Spinus pinus (Wils.), skin 1

Parker, A. C. Albany

Phoebe, Sayornis phoebe (Lath.), eggs..... 4
Fish crow, Corvus ossifragus Wils., egg..... 1
Red-winged blackbird, Agelaius phoenicius (Linn.), eggs.. 4
Bullock's oriole, Icterus bullocki (Swains.), eggs..... 6
Red-eyed vireo, Vireosylva olivacea (Linn.), eggs..... 4
Maryland yellowthroat, Geothlypis trichas (Linn.), eggs..... 3
Long-billed marsh wren, Telmatodytes palustris (Wils.), eggs 2
Woodthrush, Hylocichla mustelina (Gmel.), eggs..... 4

Fishes

Bean, *Dr* Tarleton H. Albany

White bass, Roccus chrysops (Raf.), spec..... 3

New York Aquarium. New York

Drum, Pogonias cromis (Linn.), spec..... 1
Sunfish, Eupomotis gibbosus (Linn.), spec..... 5
Perch, Perca flavescens (Mitchill), spec..... 5
Pearl roach, Abramis crysoleucas roseus Bean, spec..... 5

Reptiles

Klein, A. J. Albany. Python, Python sebae Gmel., skull... 1

Batrachians

McCann, *Mr.* Albany. Bullfrog, Rana catesbiana Shaw, spec. 2

Crustacea

Alexander, Charles P. Johnstown

Oniscus asellus Linn., spec..... 1
Cyclisticus convexus (De Greer), spec..... 1
Metaponorthus pruinosus (Brandt), spec..... 2

Anonymous. Limulus polyphemus Linn..... 1

Arachnida

Alexander, Charles P. Johnstown

Prothesima ecclessiastica (Hentz), spec..... 1
Gnaphosa conspersa Thorell, spec..... 1
Clubiona rubra Keys., spec..... 1
Theridium frondeum Hentz, spec..... 1
Steatodes borealis (Hentz), spec..... 1
Lyniphia insignis Blackw., spec..... 1
L. mandibulata Em..... 1
L. phrygiana Koch., spec..... 1
Epeira decipiens Fitch, spec..... 3
E. parvula Keys., spec..... 1
E. sclopetaria (Clerck), spec..... 2
E. stellata (Walck.), spec..... 2
E. trifolium Hentz, spec..... 4
E. trivittata Keys., spec..... 2
Argyroepeira hortorum (Hentz), spec..... 3

Microepeira radiosa (McCook), spec..... 1
Xysticus gulosus Keys., spec..... 1
X. quadrilineatus Keys., spec..... 1
X. stomachosus Keys., spec..... 1
X. triguttatus Keys., spec..... 2
Coriarachne versicolor Keys., spec..... 1
Misumena vatia (Clerck), spec..... 4
Runcinia aleatorius (Hentz), spec..... 1
Tibellus duttoni (Hentz), spec..... 1
Philodromus rufus Walck., spec..... 1
Lycosa communis Em., spec..... 1
L. ocreata Hentz, spec..... 1
Pirata montanus Em., spec..... 1
Pardosa pallida Em., spec..... 1
Dolomedes tenebrosus, Hentz, spec..... 1
Philaeus princeps (Peckham), spec..... 1
Eris octavus Hentz, spec..... 2
Epiblemun scenicum (Clerck), spec..... 3
Chelifer muricatus Say, spec..... 1

Myriapoda

Alexander, Charles P. Johnstown
Linotaenia fulva Say, spec..... 1
Lithobius forficatus Linn., spec..... 1
Spirobolus marginatus Say, spec..... 1

Mollusca

Alexander, Charles P. Johnstown
Succinea obliqua totteriana Lea, spec..... 1
Cochlicopa lubrica (Müller) spec..... 1
Baldwin, L. F. Albany
Limax maximus Linn., spec..... 1
Clarke, *Dr* **John M.** Albany
Oleacina truncata Gmel., spec..... 1
Zonites algirus Linn., spec..... 1
Pyramidula perspectiva, Say, spec..... 16
P. rotundata Müller, spec..... 2
Polygyra clausa Say, spec..... 2
P. exoleta Binney, spec..... 2
P. profunda Say, spec..... 2
P. thyroides Say, spec..... 2
Acavus haemastoma (Linn.), spec..... 1
Amphidromus perversus (Linn.), spec..... 1
Zaphysema macmurrayi C. B. Adams, spec..... 2
Sagda alveare Pfr., spec..... 6
S. jayana C. B. Adams, spec..... 6
Pleurodonte jamaicensis (Gmel.), spec..... 2
Leucochroa candidissima (Drap.), spec..... 2

Camaena cicatrosa (Müller), spec..... 1
Helicella ericetorum (Müller), spec..... 1
H. caespitum Drap., spec..... 2
Hygromia rufescens (Penn.), spec..... 2
Helicigona arbustorum (Linn.), spec..... 2
H. lapicida (Linn.), spec..... 2
Helix aspersa Müller, spec..... 1
H. leucorum castanea Olive., spec..... 1
H. ligata gussoneana Sh., spec..... 2
H. nemoralis Linn., spec..... 3
H. pisana Müller, spec..... 3
H. pomatia Linn., spec..... 2
H. vermiculata Müller, spec..... 2
Bulimus species, spec..... 1
Archachetina camerunensis (d'Ailly), spec..... 1
Rumina decollata (Linn.), spec..... 4
Planorbis corneus (Linn.), spec..... 1
Ampularia corrugata Swains., spec..... 2
A. fasciata Linn., spec..... 1
Paludina lecythoides Benson, spec..... 1
Adamsiella variabilis (Adams), spec..... 1
Lucidella aureola (Fer.), spec..... 1
Helicina costata Gray, spec..... 2
H. major Gray, spec..... 1
H. neritella Lam., spec..... 1

Purchase

Mammals

Elliott, Joseph. Beaver River
Porcupine, Erethizon dorsatus (Linn.), skins..... 4
Klein, A. J. Albany
Gray fox, Urocyon cinereoargenteus (Schreber), skin 1
Ward's Natural Science Establishment. Rochester
Moose, Alces americanus Jardine, group of mounted specimens 3

Birds

Acker, C. F. Conesus Lake
Double-crested cormorant, Phalacrocorax auritus (Less.) mounted specimen 1
Gowie, W. D. East Greenbush
American bittern, Botaurus lentiginosus (Montag.), skin 1
White, Peter. Albany
Short-eared owl, Asio flammeus (Pontop.), skin..... 1

Fish

Sea robin, Prionotus carolinus (Linn.), spec..... 1

Collection

Mammals

Virginia deer, Odocoileus virginanus borealis Miller, skins 2
Cottontail, Sylvilagus transitionalis (Bangs), skins.... 1
Porcupine, Erethizon dorsatus (Linn.), skin..... 1
Brown rat, Mus norvegicus Erxleben, skins..... 5
Woodchuck, Arctomys monax (Linn.), skins..... 2
Chipmunk, Tamias striata lysteri (Rich.). skins..... 2
Common mole, Scalops aquaticus (Linn.), skin..... 1
Large brown bat, Vespertilio fuscus Beauvois, skin..... 1
Red bat, Laziurus borealis (Müller), skins..... 2

Birds

Green heron, Butorides virescens (Linn.), skin..... 1
Flicker, Colaptes auratus luteus Bangs, skin..... 1
Crow, Corvus brachyrhynchos Brehm, skin..... 1
Starling, Sturnus vulgaris Linn., skin..... 1
Redpoll, Acanthis linaria (Linn.), skins..... 4
American goldfinch, Astragalinus tristis (Linn.), skin..... 1
Pine siskin, Spinus pinus (Wilson), skin..... 1
Tree sparrow, Spizella monticola (Gmel.), skin..... 1
Chipping sparrow, Spizella passerina (Bechs.), skin..... 1
Slate-colored junco, Junco hyemalis (Linn.), skin..... 1
Myrtle warbler Dendroica coronata (Linn.), skin..... 1
Black-poll warbler, Dendroica striata (Forst.), skin..... 1
Pine warbler, Dendroica vigorsii (Aud.), skin..... 1
Brown creeper, Certhia familiaris americana (Bonap.), skin 1
Golden-crowned kinglet, Regulus satrapa Licht., skins..... 2
Olive-backed thrush, Hylocichla ustulata swainsoni (Cab.), skin 1
Hermit thrush, Hylocichla guttata palasii (Cab.), skin. 1

Fishes

Sunfish, Eupomotis gibbosus (Linn.), spec..... 1
Perch, Perca flavescens (Mitchill), spec..... 3
Roach, Abramis crysoleucas (Mitchill), spec..... 1

Reptiles

Ring-necked snake, Diadophis punctatus (Linn.), spec..... 1
Water snake, Natrix sipedon (Linn.), spec..... 1
Garter snake, Thamnophis sirtalis (Linn.), spec..... 3
Snapping turtle, Chelydra serpentina (Linn.), spec..... 2
Painted turtle, Chrysemys picta (Schneider), spec..... 1
Spotted tortoise, Clemmys guttata (Schneider), spec..... 2

Batrachians

Spring peeper, Hyla pickeringii (Holbrook), spec..... 3
Tree toad, Hyla versicolor Le Conte, spec..... 2
Wood frog, Rana sylvatica Le Conte, spec..... 3
Bullfrog, Rana catesbeiana Shaw, spec..... 1

Total 312

ARCHEOLOGY

Collection

Burmaster, E. R. Port Jervis site
Jesuit rings 7
Iron rings 11
Pewter ring, glass setting..... 1
Bronze spoon..... 1
String small brass beads..... 1
String large white beads..... 1
String small white beads..... 1
String blue glass and amber beads..... 1
Moorish beads 3
Shell gorgets 2
Preserved fabric, fragment..... 1
"R. Tippet" pipe 1
2 arm bands of copper..... 2
Skeletons, parts of, including skulls..... 30
Brass buttons 30
Hawk bells 2
Bronze bell 1
Iroquois pipes 2
Pipe bowl 1

Parker, A. C.
Gorget, broken 1
Arrowheads 30
Celt 1
Net sinkers 5
Hammer stones 2
Brass, worked fragments 4
Rude stone axes 2

Luther, D. D. Naples. From graves on Canandaigua lake
Rheolite knife 1
Stone tubes 3
Native copper chisel 1
Strings of shell beads 2
Pipe 1

Exchange

American Museum of Natural History. New York
Bannerstone, Ulster co..... 1
Bannerstone, Philipstown 1

Bird amulet, Sullivan co..... 1
Gorget (1 hole, broken) Tuthill township, Ulster co..... 1
Gorget (2 holes, broken) Grinnell, New Hamburg, Dutchess co..... 1
Grooved axe, Westchester co..... 1
Grooved axe, Kingston, Ulster co..... 1
Grooved club, Saugerties, Ulster co..... 1
Grooved adze, Indian Brook, Philipstown..... 1
Celt, New Hackensack, Dutchess co..... 1
Celt, Plumbush, Philipstown..... 1
Celt, Springtown, Ulster co..... 1
Gouge, Lagrange, Dutchess co..... 1
Pestle, Stockport, Columbia co..... 1
Hammerstone, Saugerties, Ulster co..... 2
Sherds 5
Net sinker, Esopus, Ulster co..... 1
Net sinker, Plumbush..... 1
Net sinker, Philipstown..... 1
Arrow points..... 16

ETHNOLOGY

Purchase and collection

Parker, A. C.

Delaware spoon, Grand River, Ont..... 1
War club, for dancing uses only..... 1
War club, carved with symbols of clans..... 1
Deer buttons, Guskaeh, set of..... 8
Unfinished gourd rattles, to show process..... 6
Brooch said to have been worn by Red Jacket..... 1
Modern brooches..... 2
Pestle 1
Mat, Chippewa 1
Eagle pole 1
Striker for pole..... 1
Spoon, new 1
Jerked venison on string..... 1
Drawings illustrating Seneca traditions..... 5
Beaded cap 1
Onondaga beaded cap..... 1
Beaded bag 1
Panther claw 1
Corn baskets 2
Corn baskets, series used for planting, harvesting and sifting..... 8
Carving on tree trunk..... 1
False face 1
Wolf mouth mask..... 2
Medicine masks 3
Wind blower mask..... 1
Bark barrel made of elm bark..... 1
Bark barrel, birch..... 1

Algonquin birch bark canoe 1
Paddles 2
Indian corn on strings, varieties 5
Indian bread 1
Paddles carved with figurines 1
Baby moccasins, pair 1
Burden strap, woven of elm bark 1
Muskrat pelt stretcher 1
Bark rattle 1

Burmaster, E. R.
Seneca brooches 2

Purchase

Schmid, A. A. Albany
1 string of Dutch roanoke wampum 1
Beaded bag 1

Speck, *Dr* **F. G.** Philadelphia, Pa.
Huron toy bow 1
Huron spoons 3
Dolls 2
Beaded pockets 2
Snowshoe needle 1
Snowshoe punch 1

Donation

Alexander, C. P. Fonda
Pottery, fragments 10
Arrow points 5

Hutchinson, *Hon.* **Frank.** Albany
Potsherds 20
Animal bones 25
Pipe bowl 1

Lee, E. Gordon. Canandaigua
Large adzlike celt, fine specimen 1

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AGE AND RELATIONS OF THE LITTLE FALLS DOLOMITE (CALCIFEROUS) OF THE MOHAWK VALLEY

BY E. O. ULRICH[1] AND H. P. CUSHING

Introduction

In a recent paper Cushing made the following statement about the Little Falls dolomite:[2]

In the correlation table on a previous page the Little Falls dolomite (the local name of the supposed Beekmantown of the Mohawk valley) is given as the equivalent of division A of the Champlain valley and of the Theresa formation of the Watertown region. It should be frankly stated at the outset that this is the element in the table whose precise position and relationship is quite uncertain. . . Ulrich's discovery of the unconformity between divisions A and B in the Champlain valley, necessitating the separation of division A from the Beekmantown formation, at once raised the question as to whether the entire Little Falls dolomite may not lie below the horizon of the unconformity and hence not be Beekmantown at all, but be properly correlated with division A and the Theresa formation and possibly even with the Potsdam. . . There is a second doubtful matter connected with the Little Falls dolomite, namely, whether or not it is a single formation. Vanuxem carefully distinguished the upper portion of the formation, the so called "fucoidal layers," from the remainder, and he has been followed in this by most other observers in the district. . . either the bulk of the Little Falls dolomite is of substantially the same age or else there is an undiscovered unconformity between it and the fucoidal layers.

During the summer of 1909 an effort was made to gain the information whose lack was indicated by the quotation above. Cushing and Ruedemann made a careful, detailed study of the section about Saratoga, following which Ulrich was shown over the section. Thereafter Ulrich and Cushing studied a series of sections, commencing at Ticonderoga in the Champlain valley, passing south to the Mohawk and thence west to Little Falls and Newport. In much of this work Ruedemann also participated.

In the following account of the results of the work, the bulk of the paper has been written by Cushing, with an occasional comment or insertion by Ulrich. The section on the "Stratigraphic position of the Potsdam, Little Falls and Tribes Hill

[1] Mr Ulrich's contribution to this paper is published with the consent of the Director of the United States Geological Survey.

[2] Geol. Soc. Am. Bul. 19:174.

formations" was written by Ulrich, and the final chapter on oscillations is a joint production.

The section. The rocks with which this paper is especially concerned are those heretofore classed as Potsdam and Beekmantown (Calciferous). At Ticonderoga we found the ordinary Champlain succession of these rocks, Potsdam sandstone, grading up into division A of the Beekmantown through a series of passage beds, and this followed by the other four divisions of the Beekmantown, as established by Brainerd and Seely. The Potsdam is chiefly a vitreous, well cemented, light colored sandstone, with some weaker beds with calcareous cement in the upper portion. The passage beds consist of alternating beds of vitreous sandstone, calcareous sandstone, and gray dolomites which are usually somewhat sandy. With disappearance of the sandstone beds we pass into division A, chiefly a dolomite formation, largely of dark gray, finely crystalline beds below, running up into more coarsely crystalline, very light gray beds above, which are apt to be full of chert. Though not positive in the matter we are disposed to believe that Brainerd and Seely regarded the latter as forming the lower portion of their division B. At all events we find an unconformity at their summit wherever we have seen the horizon exposed, and we class them with the darker colored dolomites beneath. Frequent reefs of Cryptozoon, chiefly C. p r o l i f e r u m, are found in both the dark and light colored parts of the formation, and the summit is very apt to be formed of a massive, Cryptozoon reef, often heavily silicified. Lying on these in the section we measured at Ticonderoga appear beds which seem to belong to division C. The beds of dove limestone which constitute the most distinctive part of division B at Shoreham, Vt. and elsewhere in the Champlain valley are absent in the Ticonderoga section, apparently because of nondeposition. Division C is followed in order by the beds of D and E, and the last by lower Trenton, but the succession is somewhat disturbed by faulting.

Our section at Whitehall exhibited the Potsdam, passage beds and overlying dolomites, reaching up into the coarse, light colored, upper beds, but the summit and the overlying beds were not reached. What was seen was exceedingly like the corresponding part of the Ticonderoga section.

Again at Saratoga the section was quite similar, though with two prominent differences. Instead of the Potsdam grading

upward through passage beds into dolomite, the passage beds were between it and limestone, which was, in turn, followed by dolomite. This is the limestone from which Walcott obtained the Saratogan fauna which he described. It seems to us to be a calcareous phase of the lower portion of the dolomite formation. We are proposing for it the name "Hoyt" limestone and regard it as merely a local member of the dolomite. The name "Greenfield" limestone, given to it by Clarke and Schuchert, was preoccupied and must hence be replaced.

At Saratoga also there is no trace whatever of the beds of the four upper divisions of Brainerd and Seely's Beekmantown, B-E inclusive; instead the limestone heretofore called Trenton rests directly on the dolomite of division A. The Potsdam is thinner than at Whitehall and Ticonderoga, the loss being from the base.

Passing from Saratoga to the Mohawk valley the Potsdam rapidly thins out to disappearance along with the passage beds, letting the dolomite down on the Precambric. The dolomite formation, however, remains substantially as before, and is overlaid by the more calcareous formation which Vanuxem called the "fucoidal" beds. For these we propose the name "Tribes Hill" limestone, restricting the Little Falls dolomite to the beds beneath. The one overlies the other unconformably. The Tribes Hill thins westward and disappears west of Little Falls, letting the overlying Lowville limestone down on the dolomite.

The general section then, as we interpret it, is as follows:

Beekmantown	Upper divisions of the Beekmantown; unnamed as yet
	Tribes Hill limestone
	Unconformity
Saratogan	Little Falls dolomite; Hoyt limestone as a local, basal phase
	Theresa formation; passage beds
	Potsdam sandstone

Historical

It is not intended here to give an exhaustive résumé of the literature which deals with the district, but merely to indicate some of the more important papers.

Vanuxem, 1842.[1] In reporting on the Calciferous group in the third district, Vanuxem distinguished three varieties of the rock:

The first silicious, compact, and perhaps a continuation of the Potsdam sandstone; the second a mixture of yellow sand and carbonate of lime, in irregular layers, the mass from whence the name *Calciferous sand rock* was derived; and third a mixture of the Calciferous material, which is usually yellowish, and of compact limestone, containing also some slaty matter. The action of the weather gives these layers the appearance of a gothic fretwork. These materials are often coated over with a greenish shale; and the whole mass has been designated, in the annual report, by the name of *Fucoidal layers*. In the annual reports the fucoidal layers were separated from the Calciferous sand rock, in consequence of always observing that they were above the great mass of the latter rock; overlooking the fact, as it seemed to be of little importance, that the fucoidal layers were always covered by a few, or more, layers of the Calciferous rock. A reattention to the subject was caused by the observations of Dr Emmons in the second district, where the mass above the fucoidal layers is greater than the one below it; the combined observations of the two districts showing that the two constitute a group, in which the fucoidal layers are included, and therefore a subordinate mass.

Fossils are rare in the Calciferous sand rock, but in the fucoidal layers there are many individuals, though the kinds are few. Most of them are peculiar to this rock. . .

As a marked difference exists between the Calciferous sand rock and the fucoidal layers, though they form one group from the intercalation of the latter, they will be treated separately, from the rule which separates objects which are different.

Comment. The above excerpts, given substantially in Vanuxem's own words, show plainly that this excellent observer was so impressed with the differences between the two formations that he described them separately, and likely would not have classed them together at all, except for the reported conditions in the second district, unfamiliar territory to him. He noted the differences in lithology and in the fossils, and also that the fucoidal layers thin out westward, being very thin at Little Falls.

Emmons, 1842.[2] Emmons, in the second district, which included the entire east and north sides of the Adirondack region, found the Calciferous in greatest variety and in greatest thickness. In the Champlain valley he included the lower Chazy in the Calciferous, and in the lower Black River region, the beds of

[1] Geol. N. Y. 3d Dist. p. 30–38.
[2] Geol. N. Y. 2d Dist. p. 105–6.

Stones River age, since separated as the Pamelia limestone. He attempted to recognize the fucoidal layers in his district, but states that they lie just above the Potsdam instead of occurring at the same horizon as along the Mohawk, and it is plain that the term, as he used it, referred to the passage beds of the Theresa formation, and not at all to the Tribes Hill limestone.[1]

Hall, 1847. In volume 1 of the *Palaeontology,* Hall describes and figures a few fossils from the Potsdam sandstone and the Calciferous sand rock. The Calciferous forms, with the exception of Lingulepis acuminata which is from the basal part, and of four species found loose, came from the upper part of the Little Falls dolomite and from the overlying, calcareous layers (Tribes Hill limestone) along the Mohawk.

Hall, 1884.[2] Describes Cryptozoon proliferum from the Calciferous of Saratoga county, with description of the genus.

Walcott, 1879–91.[3] In a series of publications Walcott refers the Potsdam sandstone to the Cambric, describes the fauna from the Hoyt limestone, and recognizes it as Cambric, though referring it at first to the Calciferous. He regards the Hoyt limestone as a local, calcareous phase of the upper part of the Potsdam sandstone and states that Lingulepis acuminata ranges up into the Calciferous sand rock, and that a species of Ophileta ranges down into the Potsdam. He draws the line between the Cambric and Lower Siluric north of the Adirondacks between the Potsdam and the Calciferous sand rock; about Saratoga in the lower part of the dolomite above the horizon of the Hoyt limestone.

Comment. Walcott's work was, of course, a great advance over everything that had preceded. We differ from his conclusions chiefly in regarding the Hoyt limestone as on the horizon of the basal portion of the Calciferous rather than of the upper part of the Potsdam; in holding that substantially the same fauna characterizes the upper Potsdam, passage beds, and lower portion of the Calciferous; and in classing the whole of the Calciferous of the Saratoga region and all of the Calciferous of the Mohawk valley, except the part here distinguished as the Tribes Hill limestone, with the Potsdam as Saratogan.

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[1] *Op. cit.* p.270.

[2] N. Y. State Mus. 36th An. Rep't Nat. Hist. pl.6, description.

[3] N. Y. State Mus. 32d An. Rep't.
Science, 3:136–37.
U. S. Geol. Sur. Bul. 30, p. 21–22.
U. S. Geol. Sur. Bul. 81, p. 205–7, 341–47, 363.

Brainerd and Seely, 1890.[1] In a most important paper Brainerd and Seeley give results of the first careful and detailed study made of the Calciferous of the Champlain valley, disclosing its great thickness and its considerable fauna. They distinguish five subdivisions of the formation which they call divisions A-E, inclusive, and map several of the most important areas in detail. The work on the whole was well done and has formed the basis for all subsequent discussion of these rocks in the Champlain valley.

Prosser and Cumings, 1896–1900.[2] In two publications are given a series of carefully measured sections with discussion, from Trenton Falls on the west through the Mohawk valley to the Saratoga region on the east. The thickness of the Little Falls dolomite in the Mohawk valley was made known for the first time and, following Vanuxem, the fucoidal layers were carefully distinguished from the dolomite beneath.

Cleland, 1900–3.[3] Announces discovery of an abundant fauna in the Mohawk valley Calciferous (fucoidal layers) which is described, and the horizon traced from Fort Hunter and Tribes Hill to Little Falls with collection of fossils at several points.

Cushing, 1908.[4] Gives a general description of the section in Jefferson county, describing the Theresa formation — a thin series of passage beds and following magnesian limestones — which directly overlies the Potsdam sandstone and is unconformably overlain by the Pamelia formation, of late Stones River age. The Theresa formation was so thin and so lithologically similar from base to summit, that it was not suspected that more than one formation was represented by it. This, however, proves to be the case, as will be later shown.

It is also argued in this paper that division A of the Beekmantown more properly belongs with the underlying passage beds and Potsdam than with the purer limestones of the remainder of the Beekmantown, and that with this readjustment the upper Cambric (Ozarkic) and the Lower Ordovicic are separated by an unconformity everywhere in northern New York.

Purpose of this paper

Our comparative study of the region has, we think, made clear the correlation of the Calciferous of the Champlain and Mohawk

[1] Am Mus. Nat. Hist. Bul. 3:1.
[2] N. Y. State Geol. 15th An. Rep't, p.619–59.
N. Y. State Mus. Bul. 34.
[3] Am. Pal. Bul. 13, 18.
[4] Geol. Soc. Am. Bul. 19:155–76.

valleys and seems to us also to show that the Little Falls dolomite (Division A and the lower part of B) does not properly belong with the Beekmantown, either structurally or faunally, and has been heretofore classed with it simply on the basis of supposed lithologic resemblance; that it is separated from the remainder of, or rather the true Beekmantown, by an unconformity, while it invariably grades into the Potsdam beneath through a series of passage beds; and that faunally also its association is with the Potsdam, the Hoyt limestone of the Saratogan region being merely a more calcareous and more fossiliferous phase of its lower portion, of very local character, rather than a phase of the Potsdam.

Detailed sections

Commencing at Ticonderoga on Lake Champlain the sections will be given in order, passing to Whitehall, 20 miles south of Ticonderoga; to Saratoga, 35 miles farther and south-southwest from Whitehall; to Cranesville in the Mohawk valley, 20 miles southwest of Saratoga; and then west through the valley to Little Falls, Middleville and Newport, 35 to 45 miles away.

Section at Ticonderoga

Brainerd and Seely have mapped and discussed the Beekmantown section in the vicinity of Ticonderoga. It is but a few miles west of their type locality at Shoreham, and they map all five of their subdivisions of the formation. It may thus be regarded as giving a quite typical representation of the Beekmantown section of the Champlain valley.[1]

Since our purpose was a detailed comparison of a portion of the section with sections elsewhere, we made no effort to study the whole in detail. Potsdam sandstone is exposed in the creek through the village, and commencing 60 feet above the creek level we measured the following section up the hill to the north, known as Mount Hope, the 60 foot gap probably consisting partly of Potsdam and partly of passage beds:

SECTION JUST NORTH OF TICONDEROGA

	Feet	Inches
34 Light gray, finely crystalline limestone, to top of exposure	1	8
33 Gray, calcareous sandstone	7	

[1]Am. Mus. Nat. Hist. Bul. 3:10–14.

		Feet	Inches
32	Blue gray dolomite; cross-bedded, rather coarse grained; frequent drusy cavities with calcite and quartz; very sandy midway with chert pebbles and flat, fine grained pebbles	3	6
31	Medium grained, gray, crystalline limestone; many nodules of crystalline calcite centrally	11	
30	Hard, vitreous sandstone, irregular at base over the nodular surface of the limestone beneath	1	
29	Gray, crystalline limestone, in four beds, finer grained toward top	4	
28	Gray white sandstone, somewhat calcareous	1	10
27	Hard, vitreous, whitish sandstone, coarsely ripple-marked above	2	
26	Gray crystalline limestone, with calcite nodules	1	3
25	Alternations of thin, slaty limestone and thin seams of gray, magnesian limestone, much laminated	12	
24	Upper half of gray dolomite, lower of dark gray, oolitic limestone	1	7
23	Earthy, magnesian, rotten limestone, surface nodular and of red color		7
22	Dark gray, oolitic, magnesian limestone, ovules weathering blackish	4	6
21	Fine grained blue limestone, weathering drab; earthy and somewhat laminar; upper 2 inches shaly and with nodular surface which weathers red	5	4
20	Similar to that above; very uneven upper surface with 1 inch to 3 inches red, laminar shale as cover, 3 feet, 6 inches to	4	
19	Dark gray, oolitic, magnesian limestone, ovules weathering blackish		8
18	Blue, earthy, fine grained, somewhat laminar limestone; weathers drab	2	4
17	Dark blue gray, crystalline, suboolitic limestone; upper surface is irregular and weathers red	1	2
16	Thin, sandy, blue limestone bands with shale partings, and one 4 inch seam of cross-bedded sandstone; upper 1 foot very thin bedded, and reddish; holds Lingulepis acuminata	3	6
15	Thin, irregular, shaly limestone, with fucoidal markings and Lingulepis acuminata		4

		Feet	Inches
14	Hard, whitish, vitreous sandstone		10
13	Dark blue gray limestone, finely crystalline, heavy bedded, frequent grains of fine quartz sand	7	
12	Hard, white, vitreous sandstone	2	3
11	Dark gray blue, calcareous sandstone, weathering to brown, rotten stone, especially above	4	4
10	Gray, finely crystalline, somewhat magnesian limestone, with occasional sand grains; thick bedded; upper surface ripple-marked	9	3
9	Irregular parting of shaly limestone with fucoidal markings		2
8	Gray, subcrystalline limestone, with sparing quartz grains; lower portion laminated and mottled with black films	2	
7	Dark to light gray, subcrystalline, magnesian limestone; thick bedded; many rounded sand grains; calcite nodules in upper portion	7	
6	Gray, magnesian limestone like that below	1	8
5	Concealed	1	8
4	Gray limestone like that beneath but lighter in color	1	
3	Fine grained, finely crystalline, gray, magnesian limestone, with fine, interrupted black lines; fucoidal markings; sand grains abundant on upper surface, otherwise sparse	2	
2	Shelly, laminar, calcareous sandstone, with streaks of pure sandstone; fucoidal markings	3	
1	Blue, crystalline limestone with occasional small, rounded sand grains	1	3
	Total thickness	112	8

This section is on the general horizon of the Hoyt limestone of the Saratoga section, though including somewhat more than that, both at top and bottom. It is also the same as the lower portion of the Whitehall section and shows the beds which are concealed there. A somewhat unusual feature of it is the distance upward through which sandstone layers of Potsdam characters run. According to Brainerd and Seely's map they regarded the lower part of this section as belonging to division A and the upper to B.

One mile to the east of this section is another which shows higher beds, an additional thickness of about 100 feet being exhibited. The section is exceedingly similar to that of the upper portion of the Little Falls dolomite at Saratoga, bluish gray, finely crystalline dolomite below, often with bad odor when freshly broken, with many nodules of crystalline calcite, often drusy, and with coarser grained, whitish, crystalline dolomite above, with much black chert; the section capped by a massive 6 foot reef of Cryptozoon, much of which is chert. This is directly and unconformably overlaid by beds which seem to us to belong to division C; certainly they have the lithologic character of that division. These are followed in their turn, going north, by the beds of divisions D and E.

Discussion. The bulk of this second section is mapped by Brainerd and Seely as belonging to division B. They describe the division as follows:

> Dove-colored limestone, intermingled with light gray dolomite, in massive beds; sometimes for a thickness of 12 to 15 feet no planes of stratification are discernible. In the lower beds, and in those just above the middle, the dolomite predominates; the middle and upper beds are nearly pure limestone.[1]

We found no dove limestone in the section. Likely the light gray dolomite is that forming the upper part of our section, though if it be, we fail to understand the lack of mention of the chert which we find in it everywhere abundantly. In any case it is the same horizon which we find everywhere to characterize the summit of the Little Falls dolomite. In this section it is, as we believe, in uncomformable contact with division C and this is followed by the whole of D and E, the two upper members of the Champlain Beekmantown. Except where eroded away during the time interval which followed, the summit of the Little Falls dolomite at Ticonderoga and elsewhere is usually a Cryptozoon reef, often heavily charged with chert, as is the case here.

Section at Saratoga

The Saratoga district is considerably faulted; glacial drift is widespread and often heavy, and a complete, detailed section can not be made out from study of the surface outcrops. The Mohawkian rocks rest on an uneven, eroded surface of the dolomite group, varying beds of each group being at the contact in the different exposures. The general section is as follows:

[1] *Op. cit.* p. 2.

Trenton limestone; with usually a small thickness of Black River limestone beneath

Unconformity

Little Falls dolomite; light gray to dark gray, crystalline to subcrystalline dolomite, sharply bounded rhombs embedded in a cement which is more or less calcareous and dissolves away leaving surfaces of sandy appearance; certain layers are full of nodules of crystalline calcite, others are drusy and hold calcite and quartz crystals; black and gray cherts are frequent at certain horizons; a Cryptozoon reef occurs in the upper part of the formation in a dove limestone band; otherwise fossils are very scarce. Thickness at least 150 feet and possibly 200 feet

Hoyt limestone member; blackish, subcrystalline, pure or only slightly magnesian limestone alternating with beds of blue and light gray dolomite; quartz sand grains in some of the beds, increasing in amount below; in the lower portion beds of calcareous sandstone and more rarely of quartzose sandstone; contains many beds of black oolite, most abundant near the base; contains Cryptozoon, trilobites, gastropods, and Lingulepis acuminata at many horizons. Thickness 80–120 feet

Passage beds from the Hoyt limestone to the Potsdam sandstone; alternating beds of hard, vitreous sandstone, gray, calcareous sandstone, blue or gray, crystalline dolomites and magnesian limestones, and black, oolitic beds; contain trilobites and Lingulepis acuminata. Thickness 40–60 feet

Potsdam sandstone; light colored, vitreous sandstone, with occasional layers of calcareous sandstone in the upper portion, and more or less coarsely conglomeratic beds at base; thickness variable because of overlap on an irregular erosion surface of Precambric rock; from 60 feet to more than 200 feet

So far then as can be told from the surface exposures the thickness of the beds between the Potsdam and the Mohawkian is from 300 to 350 feet.

The most complete and continuous section of the upper beds of the Little Falls dolomite seen is that along the roadside east of Highland Park. Here the following section was measured.

SECTION EAST OF HIGHLAND PARK

		Feet
14	Gray, subcrystalline dolomite, with a small amount of calcite cement; great masses of gray to black chert at summit, and in smaller amount at lower horizons; frequent irregular spots and films of coarsely crystalline calcite, to top of exposure	7
13	Medium coarsely crystalline, light gray dolomite, containing locally much gray and black chert; somewhat brecciated along ancient dislocation surfaces, the interspaces now filled by blackish, subcrystalline calcite	9
12	Laminated layer of light and dark gray, subcrystalline dolomite, with small nodules of crystalline calcite	1
11	Gray white, subcrystalline, hard dolomite, with frequent drusy cavities lined with dolomite, calcite and quartz crystals, quite like those in the Little Falls region, the dolomite crystals having formed first and the quartz last	5

The above section is shown in the Maple ave. quarry near the fault line, at the north edge of Saratoga Springs; from the quarry the basal layer can be directly traced around to the north along the hillside to where it comes out on Broadway and forms the upper bed of the section shown down the hill toward St Clements.

		Feet
10	Medium coarsely crystalline, gray to gray white dolomite, somewhat mottled in appearance, with some calcite cement between the dolomite rhombs; very full of chert	12
9	Very massive, gray, granular to subcrystalline dolomite, full of large and small nodules of crystalline calcite	10
8	Unexposed	12
7	Massive layer of gray, granular dolomite with calcite spots, quite like that above gap	5
6	Dark gray, hard, finely crystalline dolomite, bad smelling when freshly broken; occasional small cherts, and spots of crystalline calcite; very massive and irregularly bedded	10
5	Somewhat lighter colored than that above, less odor and with no chert, otherwise similar	10

		Feet
4	More of the dark gray, evil smelling dolomite, like that above; all is somewhat porous, the voids between the dolomite rhombs not thoroughly cemented up; there is always a small percentage of calcite cement	11
3	Concealed	11
2	Gray, finely crystalline dolomite, lighter colored than that above and below, very massive, marked with dark colored lines, and containing some chert	15
1	Dark, blue gray, porous dolomite, at base of section	1
		119

This section terminates at the north in the angle between two branches of a fault, making it impossible to determine what thickness of similar beds may lie beneath. The light gray, crystalline dolomites of the upper portion of the section continue on to the south through Saratoga, with likely some additional beds which do not appear in the section, but the thickness of such can not be great — probably less than 15 feet. Four miles west of Saratoga a hill composed of these same beds is capped by a dove limestone layer which is a great Cryptozoon reef, and which is likely at a somewhat higher horizon than any bed of the section; but it lies upon light gray, crystalline dolomites precisely like those which form the upper beds of the Highland Park section and can not be greatly higher than these.

The best section of the lower beds, Potsdam sandstone and Hoyt limestone, is found along the Adirondack Railroad to the west of Saratoga. It is as follows, the beds being numbered from below upward:

CONSECUTIVE SERIES OF SECTIONS EXPOSED IN CUTS ALONG THE ADIRONDACK RAILROAD AND NEARBY QUARRIES BETWEEN GREENFIELD STATION AND SARATOGA

40 Exposures at Hoyt quarry; hard, blue to blue black, subcrystalline to crystalline magnesian limestones, largely of dolomite rhombs with calcareous cement; 1 foot from the top is a Cryptozoon reef, and the base is composed of another, the one shown by the roadside near the farmhouse, from which Hall originally described *Cryptozoon proliferum*; the rock is partly thin, and partly thick bedded; some of the layers

		Feet
	show coarsely crystalline calcite cement, giving large, glittering cleavage faces on freshly broken surfaces; trilobites, Lingulepis and gastropods are found from bottom to top	25

One third mile north of the Hoyt quarry is another quarry face by the roadside, capped by the same Cryptozoon layer which forms the base of the Hoyt quarry section.

		Feet	Inches
39	Dark blue, subcrystalline, magnesian limestone, full of Cryptozoon; frequent, black oolitic grains.	1	5
38	Massive beds of blue, finely crystalline magnesian limestone, with occasional sand grains; trilobite fragments	5	5
37	Thin bed of calcareous sandstone, weathering to brown, rotten stone		5
36	Two beds of dark blue, crystalline, magnesian limestone with occasional sand grains	2	5
35	Layer of dark gray, calcareous sandstone	1	7
34	Layer of light colored, vitreous sandstone, with films of darker material with calcareous cement	1	3
33	Dark colored sandstone with calcareous cement		4
		12	10

Four tenths of a mile northeast of this are two considerable cuts along the Adirondack Railroad in which the following section is shown. The hiatus between the two is estimated at 20 feet.

		Feet	Inches
32	Dark blue, subcrystalline magnesian limestone	1	3
31	Blackish oolitic dolomite	1	8
30	Dark blue, crystalline dolomite, with calcite cement, showing large, lustrous cleavage faces; holds Lingulepis acuminata		10
29	Black, oolitic dolomite, containing pebbles of mud limestone	1	8
28	Rotten, crystalline dolomite, calcite cement rapidly leaching out		5
27	Blackish, oolitic dolomite in three beds, the upper a Cryptozoon bed; frequent sand grains and many drusy cavities containing quartz and calcite crystals	2	6

		Feet	Inches
26	Easily rotting, crystalline dolomite, calcite cement, very shaly above		9
25	Hard, light colored, vitreous sandstone	1	4
24	Crystalline, bluish dolomite, poorly cemented by calcite	1	7
23	Two massive beds of blackish, subcrystalline, magnesian limestone, with frequent sand grains, to base of westerly cut	4	3
22	Concealed between the two cuts; boundary between Hoyt limestone and the passage beds to the Potsdam, about	20	
21	Rotten, brown, calcareous sandstone, blue when fresh		8
20	Hard, vitreous, light colored sandstone, banded with narrow streaks of darker colored sandstone with calcareous cement	2	4
19	Thin bedded, blue, calcareous sandstone, weathering brownish		9
18	Blue black, oolitic dolomite, frequent rounded quartz grains, many small drusy cavities	1	3
17	Blue, calcareous sandstone, weathering light colored, upper portion shaly	1	8
16	Hard, light colored, vitreous sandstone	1	6
15	Thin bedded, calcareous sandstone, somewhat oolitic, blue when fresh but rapidly weathering brown-mottled and crumbly, many drusy cavities, with calcite and quartz crystals; abundant trilobite fragments, constituting the lowest zone of these so far discovered near Saratoga	1	3
14	Light colored, vitreous sandstone	2	5
13	Bluish, nodular, finely crystalline dolomite, with a slight amount of calcite cement, shaly at top and bottom, with frequent nodules of crystalline calcite; holds Lingulepis acuminata.	2	3
12	Light colored, vitreous sandstone	1	3
11	Gray, banded sandstone, slightly calcareous	3	9
10	Alternating calcareous sandstone and crystalline dolomite, of blue gray color, large nodules of crystalline calcite in the latter; base of cut	3	
9	Concealed between this and the next cut to the east, about	30	

		Feet	Inches
8	Hard, vitreous, light colored sandstone, with darker calcareous sandstone above and below..	1	8
7	Concealed to brook exposures next east; arbitrary boundary between passage beds and Potsdam in the interval, about.....	30	
6	Light colored, vitreous sandstone, with alternating layers of darker, calcareous sandstone which weather rapidly.....	30	
5	Light colored, vitreous sandstone.....	15	
4	Concealed	4	
3	Light colored, vitreous sandstone.....	2	
2	Concealed	4	
1	Conglomerate, increasing in coarseness downward, and reaching nearly to the base of the formation.	10	

In this section we find then a thickness of 94 feet, 1 inch of the Hoyt limestone member of the Little Falls formation, counting in with it the 20 foot gap between it and the passage beds, with the summit of the member not reached; beneath it a thickness of 52 feet, 1 inch of what we class as passage beds, counting in with them the 30 foot gap between them and the Potsdam; and finally 96 feet, 8 inches of Potsdam with the base not reached, though it is unlikely that as much as 10 feet lies beneath. We find essentially the same trilobite fauna ranging through a thickness of at least 100 feet, commencing in the passage beds and continuing up through the entire thickness of the Hoyt limestone. There is a measured thickness of 119 feet of Little Falls dolomite above the Hoyt member in the Highland Park section which shows neither the base nor the summit. We are, however, disposed to think that the entire thickness of this part of the formation is not greatly in excess of this, and that the coarsely crystalline, light colored dolomite of the upper part of the Highland Park section constitutes the summit of the formation about Saratoga. In the northern part of the village just south of the quarry which furnished the top of our measured section and close to the fault are a few thin patches of Mohawkian limestone, resting upon these upper beds and apparently directly deposited upon them. The Mohawkian is a conglomerate with many pebbles of the underlying dolomite. The horizon of this contact is certainly not more than 20 feet above the top of the quarry section.

The thickness of the beds that may lie beneath the bottom of the Highland Park section and the top of the Hoyt limestone member in the Hoyt quarry, in other words the thickness of the beds belonging between the base of the former section and the top of the latter, is much less certain, but so far as can be judged from sections elsewhere the amount is not great. Estimating the Hoyt at a maximum of 100 feet and the upper member at about 150 feet, the total thickness of the Little Falls formation in the vicinity of Saratoga may be set down as approximately 250 feet. The maximum may fall a trifle under this figure, but it is quite certain that it does not exceed 300 feet. Locally, however, on account of Prémohawkian erosion the thickness may be considerably less.

At Rock City Falls, 7 miles west of Saratoga, contact with the Mohawkian is well exposed. Here this Ordovicic limestone rests upon darker colored dolomites of the Little Falls formation which seem to belong beneath the coarse, whitish rocks of the upper portion. Midway between Saratoga and Rock City Falls are other exposures which show Mohawkian limestone resting on similar beds, though the higher, coarse grained, whitish beds are near at hand, and in such situation that we can only interpret the exposures as indicating that the Mohawkian was deposited on an eroded surface of the Little Falls dolomite, beds being absent in some sections both above and beneath the unconformable line of contact that are present in others. The evidence seems clear to us that the whitish summit beds of the Little Falls have been eroded away locally, the Mohawkian in such cases resting on lower beds.

The lower part of the Mohawkian varies greatly within and in areas adjacent to the Saratoga quadrangle. As a rule the basal Mohawkian beds in this region have been assigned to the Trenton, but, so far as observed, they are in all cases older than the lowest Trenton in the type sections on West Canada creek. At the same time, however, the first Ordovicic bed to follow the Little Falls dolomite, or the Tribes Hill formation and the thin irregular wedge of Lowville where these are present, is younger than the Watertown limestone ("7 foot tier") of the Black River group. In other words, in the area between Saratoga on the east and say Canajoharie on the west, the post-Lowville Mohawkian begins with beds that are wanting along West Canada creek and Black river. At Saratoga a 6–10 foot, heavy bedded crystalline limestone is found either resting on or not more than 5 feet above the top of the Little Falls dolomite. At Rock City Falls, 6 miles west, this bed

lies about 30 feet above the dolomite, the basal layers of the underlying interval being unquestionably of the Black River group but not so low as the Lowville and probably also younger than the Watertown limestone. The Lowville is represented by 2–4 feet of beds at Tribes Hill in the Mohawk valley, but here the crystalline limestone is only 3 to 5 feet above it. The section at this locality differs further in that it contains an unusual thickness (13 to 18 feet instead of 2 to 10 feet) of somewhat shaly limestone above the crystalline bed before the Prasopora simulatrix fauna, with which the typical Trenton begins in New York, sets in. This irregularly distributed, presumably late Black River formation, intervening between the true Trenton above and the more typical Black River formations (Lowville and Watertown) beneath, will be fully described in another paper. Here it will suffice to say that it wedges out westwardly in the Mohawk valley before reaching Little Falls. So far as known its maximum aggregate thickness is about 60 feet, the lower 46 feet of which is exposed at Rock City Falls. A good thickness is shown also in the section at Glens Falls.

The work of Prof. W. J. Miller on the Broadalbin quadrangle (next west of the Saratoga quadrangle) in 1909 shows that there the Hoyt limestone is absent from the section, being replaced by unfossiliferous dolomites and probably also by beds included in an increased thickness of passage beds between the dolomite and the Potsdam.

The well drilled at the Hathorn spring in Saratoga a few years ago is reported to have begun in the Trenton limestone and to have passed through some 700 feet of limestone before reaching the Potsdam. This is a thickness at least 300 feet greater than the surface exposures indicate. The well is near a fault and it seems probable that it crosses a branch of the fault in such wise as to repeat a considerable thickness of the limestone.

Section at Whitehall

Whitehall is between Saratoga and Ticonderoga and thus, from the standpoint of distance, serves as a convenient intermediate point between the two. The district is much faulted, but a good, continuous section is afforded from the Precambric up through the Potsdam and well toward the summit of the Little Falls dolomite, simply by ascending the hill known as Skene mountain, a fault block whose summit rises sharply to more than 400 feet above the level of Wood creek. Walcott has given a detailed section of the Pots-

dam and passage beds at this point and a more generalized section of the dolomites above.[1] We were more concerned with the upper part of the section than with the Potsdam and made the following measurements down the south face of the hill, where the section seemed most complete:

SECTION OF LITTLE FALLS DOLOMITE AT SKENE MOUNTAIN NEAR WHITEHALL, N. Y.

		Feet
7	Whitish, rather coarsely crystalline dolomite, with a little chert at summit; this material forms the summit of the knob everywhere and is of greater thickness than 10 feet, that being only what is shown where the section was measured	10
6	Mostly very finely crystalline, dark gray magnesian limestone somewhat cherty above; full of irregular seams of more coarsely crystalline material which weathers less readily and forms projecting films on weathered surfaces; lower portion very massive forming high cliff; at base a single trilobite fragment was found	90
5	Very coarsely crystalline, whitish dolomite, somewhat oolitic and becoming steadily finer grained downward	30
4	Gray blue, finely crystalline dolomite with calcareous cement, weathering sandy looking, many calcite-filled cavities; at base a Cryptozoon horizon	50
3	Blackish, oolitic, magnesian limestone	20
2	Measures concealed	50
1	Passage beds: chiefly calcareous sandstone, but with alternating beds of vitreous sandstone and blackish, crystalline, sandy limestone; only a 15 foot thickness of these shows on the south face but, followed around to the west side the full thickness comes in with the large thickness of Potsdam underneath which Walcott measured, the dip being strong to the east	80
		330

This section is much like those at Saratoga and Ticonderoga. The horizon of the Hoyt limestone is largely concealed, but the black, oolitic beds above the gap are exceedingly like those as-

[1] U. S. Geol. Sur. Bul. 81, p. 345.

sociated with the Hoyt. Beds 17 to 24 of the Ticonderoga section are thought to represent the same horizon. Walcott reports Lingulepsis acuminata in the passage beds. All the upper portion of the section has the typical characters of the middle and upper parts of the Little Falls dolomite, but unfortunately the summit is not quite reached. Loose chert, apparently from the upper part of the dolomite, found 2 miles northeast of Whitehall, contains two gastropods and a cephalopod that mark the middle part of the Ozarkic in Missouri. The same beds there contain trilobites closely allied to those found in the Hoyt limestone near Saratoga.

In the National Museum is a small collection of fossils made by Walcott from 2 miles north-northeast of Whitehall which contains a half dozen specimens of the fauna of division D and demonstrates the presence of at least that member of the Beekmantown. Since Whitehall is due south of Ticonderoga and much nearer that point than Saratoga, it is quite likely that other members of the Beekmantown were deposited in this region.

Mohawk valley sections

Passing southward from Saratoga to the valley exposures the Potsdam sandstone rapidly thins and disappears, letting the passage beds and then the Little Falls dolomite down on the Precambric. The manner of disappearance seems to us to indicate plainly that the Potsdam vanishes because of overlap, and that the dolomite of the valley is the direct equivalent of that of the Saratoga and Ticonderoga sections and wholly above the Potsdam. The paleontological evidence, so far as it goes, confirms this belief.

In the most easterly of the Mohawk valley sections a limestone formation of considerable thickness, the "fucoidal layers" of Vanuxem, overlies the dolomite. This limestone is thickest at the east and thins westward to complete disappearance west of Little Falls. The published sections of Prosser and of Cleland, with the faunal studies of the latter, left no doubt of the fact of the general persistence and equivalence of both the dolomite and limestone formations throughout the valley, hence our comparative study seemed to call for sections only at the east and west ends respectively. We measured and studied sections at Tribes Hill and Cranesville at the east, and at Little Falls, Middleville and Newport at the west.

SECTION AT CRANESVILLE

		Feet	Inches
19	Irregular, thin bedded, crystalline limestone, with Solenopora compacta and other fossils; 9 inches to	2	1
18	Thin bedded, fine grained, somewhat argillaceous limestone often nodular; contains Tetradium; 4 feet to	5	
17	More coarsely crystalline, otherwise like that just beneath	2	
16	Massive, blue gray, subcrystalline limestone, often lumpy, with abundant, subangular limestone pebbles from the dolomite below; many fossils, Columnaria, Tetradium etc.; 6 to	10	
15	Dove limestone of Lowville character, often not appearing; base of Lowville; 0 to	1	
Unconformity		....	....
14	Thin bedded, earthy, gray dolomite, weathering shaly	18	
13	Unexposed	5	
12	Sandy, laminar, gray dolomite, containing Ophileta disjuncta	1	
11	Concealed	40	
10	Hard, blue gray, fine grained dolomite	2	
9	Unexposed	20	
8	Laminar, fine grained dove limestone, mottled with strings and patches of argillaceous dolomite, suggesting fucoids; contains Eccyliomphalus	25	
7	Unexposed	45	
6	Thin bedded, alternating limestone and shaly limestone, with pure limestone at base; many fossils, chiefly gastropods; base of Tribes Hill	12	
Unconformity		....	....
5	Whitish, rather coarsely crystalline dolomite on hillside between the forks of the road	15	
4	Unexposed	10	
3	Thin bedded, argillaceous, gray dolomite, very irregular above and with rolls in the lower portion	18	

		Feet	Inches
2	Light to dark gray, crystalline dolomite, many nodules of crystalline calcite, often large; many of the beds have calcareous cement and weather porous, crumbly and sandy looking	20	
1	Concealed to level of Mohawk	90	

Though this section is very imperfect, yet it gives both the upper and lower contacts of the Tribes Hill limestone with a thickness of 168 feet for the formation in this section. The base is well shown and is distinctly unconformable on the dolomite beneath. The Little Falls dolomite has the general characters that it shows in all sections, the coarsely crystalline, whitish beds above, and darker, finer grained beds below. The base of the dolomite is below the river level, but it is quite certain that the Potsdam is still in place beneath. The Amsterdam sheet, midway of which this section occurs, corners on the Saratoga sheet at the southwest and is distant only 20 miles from the Saratoga section. On the Broadalbin sheet (north of Amsterdam and west of Saratoga) Miller finds the Potsdam running all the way across the sheet from east to west. The section differs from that at Saratoga chiefly in that the Tribes Hill formation has come in between the Little Falls and the overlying Mohawkian. It differs from the Ticonderoga section in that none of the Beekmantown except the Tribes Hill division appears. The section was measured up the creek which comes into the Mohawk at Cranesville from the north, diverging from the creek up the left-hand road, 1 mile north of the river. Cumings had previously published the same section though we subdivide somewhat differently and find the thickness of the upper part less than he gives it.[1]

Section at Tribes Hill

At Tribes Hill, 8 miles west of Cranesville, we also measured the section. The locality is just across the river from Fort Hunter, where the original discovery of the fauna which Cleland described was made.[2] The section at Tribes Hill is much less complete than at Cranesville, but we have chosen it as the type locality because of the excellent exposure of the characteristic fossiliferous limestone of the formation which is found

[1] N. Y. State Mus. Bul. 34, p. 441.

[2] Am. Pal. Bul. v. 3, no. 13.

along the creek which flows southeast through the village. This section was carefully measured by Cleland and as here given is practically a reproduction of his, a few lithologic data being added.[1]

SECTION IN CREEK NORTH OF METHODIST CHURCH, TRIBES HILL

		Feet	Inches
7	Layer of compact, dove limestone, probably Lowville		4
	Unconformity	....	....
6	Rather dark gray, hard, fine grained, somewhat laminar dolomite, breaking with conchoidal fracture	12	8
5	Alternating dove limestone and sandy, laminated, magnesian limestone, in undulating, irregular layers; main horizon of Dalmanella wemplei	7	7
4	Argillaceous, yellowish dolomite, or magnesian limestone, capped by a 1 inch layer of limestone conglomerate with fossils	4	
3	Finely granular, blue limestone, which is conglomeratic and oolitic, and exceedingly fossiliferous; abundant Ribeiria and small gastropods	2	6
2	Massive, slightly argillaceous, gray, magnesian limestone, with occasional fossils	7	5
1	Blue gray limestone which is somewhat conglomeratic and contains fossils in considerable number	3	1

This section furnishes a thickness of 37 feet, 3 inches of these typical fossiliferous beds. The base of the section is nearly 200 feet above the river level, but the underlying beds are exposed in very fragmentary fashion. The dip is strong to the west and brings this horizon down to the level of the railroad at the Tribes Hill depot. A short distance east of the depot is a considerable quarry in these beds which was carefully measured by Prosser.[2] There are also quarries just west of the depot where the Lowville and overlying limestones are well shown, with the summit of the Tribes Hill limestone beneath. In both these sections there is a thickness of from 15 feet to 20 feet of gray, magnesian limestone and dolomite at the summit of

[1] Am. Pal. Bul. v. 4, no. 18, p. 6–8.
[2] N. Y. State Geol. 15th An. Rep't, p. 645.

the Tribes Hill which certainly differ from bed 6 at the top of the formation in the section in the village just given. As the Lowville and other Black River limestones are thicker in the quarry at the depot than in the village section it is thought likely that, in part, the westward dip may signify descent of the beds into an original synclinal basin in which the Tribes Hill formation retained beds that were eroded in nearby areas.

Western sections

It was our intention to study the section at Sprakers about midway of the valley, where the Precambric is brought up on the west side of the fault, and the full thickness of the "Calciferous" is shown. We were, however, unable to do so and hence can not state whether the contact between the Little Falls dolomite and Tribes Hill limestone is here exposed or not. However, considering that wherever observed the formations maintain unconformable relations to each other there seems no reason to doubt that similar conditions will be found to obtain also at Sprakers. Prosser has given two carefully measured sections at this point, one of the cliff at the West Shore Railroad cut, the other along Flat creek.[1] The Potsdam is absent, having disappeared through overlap. The first section shows a thickness of 490 feet, the lower 385 feet of which belong apparently to the Little Falls, the upper 40 feet belong certainly to the Tribes Hill, while between the two is an interval of 65 feet with infrequent exposures which in all probability belongs mostly or entirely with the Tribes Hill. The summit of the formation is not reached. Prosser reports Cryptozoon about 200 feet above the base in the Little Falls, and the Tribes Hill fauna in the upper 40 feet of the section. The Flat creek section, capped by Mohawkian limestone, shows 190 feet of rock, the upper 95 feet of which Prosser assigns to the Tribes Hill (fucoidal beds) and the lower portion to the Little Falls. Except for lack of knowledge in regard to evidence of unconformity between the two formations and the precise horizon of the break, the section is perfectly clear.

Section at Little Falls

The best section at Little Falls is that along the creek to the northwest of the town, where the upper beds and all the contracts

[1] N. Y. State Geol. 15th An. Rep't, p. 641–43.

are fully shown. The contact of the Little Falls dolomite on the Precambric is also shown, but a complete section of the dolomite is nowhere to be found on the north side of the river. The creek section follows, commencing at the base of the Trenton.

SECTION IN SMALL CREEK AT NORTHWEST EDGE OF LITTLE FALLS

	Feet	Inches
Base of Prasopora simulatrix bed of Trenton		
Hiatus	....	....
20 Brittle dove limestone; normal Lowville	7	11
19 Basal, less typical Lowville beds; dove limestone with many rounded quartz grains, in increasing amount downward	3	11
18 Shaly layers of varying thickness; base of Lowville; 0 to		3
Hiatus	....	....
17 Thin bedded and somewhat shaly layers of dove limestone and dove limestone conglomerate, the pebbles of which are embedded in crystalline limestone; considerable pyrite; found two trilobite fragments.	1	6
16 Thin bedded, hard, brittle, blue dove limestone with shaly partings; full of stems and plates of cystids and with fewer gastropods (Ophileta levata) and trilobite fragments in very bad preservation	3	6
15 Two massive beds of bluish, finely granular limestone, somewhat mottled with crystalline seams; rude fucoidal markings on surface; contains Pleurotomaria hunterensis	4	8
14 Similar to above, somewhat less like dove limestone, fine wormlike tracks on surface, upper bed weathering finely but unevenly laminar	2	8
13 Massive, 1 foot to 2 foot beds of dark, blackish gray, firm, hard, fine to medium crystalline dolomite, mottled with black streaks	7	7
12 Finely granular, gray dolomite, some beds having calcareous cement and weathering reddish and sandy looking; it is unconformable with the irregular surfaced layer beneath, whose surface the stream follows for some yards, the slope being greater than the dip of the beds above, so that an additional 6 foot thickness comes in; where thickest the basal		

		Feet	Inches
	layer is a conglomerate, with large but thin black pebbles in a reddish, calcareous matrix; in the lower portion of the bed the pebbles lie flat, but above they are disturbed and may stand on edge; base of Tribes Hill; 24 feet to	30	
11	Hard, finely granular, gray dolomite, with coarsely lumpy surface; 0 to	6	
10	Hard, finely granular, massive, gray dolomite, with some calcareous cement, and weathering reddish; a strong chert bed at the summit	24	
9	A ponderous Cryptozoon reef of varying thickness, heavily silicified forming variegated black and gray chert; its upper irregular surface is thinly covered with gray, crystalline dolomite; beneath is a varying thickness of from 4 to 7 feet of finely crystalline, dark gray dolomite	10	
8	Porous, blocky, gray dolomite, dolomite crystals in calcareous cement, weathering whitish; many sand grains	10	
7	Gray, finely crystalline, porous dolomite, calcareous cement; drusy cavities with dolomite, calcite and quartz crystals; frequent quartz grains on the upper and lower surfaces of the beds; holds thin, twisted chert plates which suggest Cryptozoon	25	
6	Finely crystalline, gray dolomite	35	
5	Medium coarse grained gray dolomite, weathering sandy looking because of calcareous cement; a Cryptozoon reef at base	30	
4	Concealed	20	
3	Medium coarsely crystalline, gray dolomite with calcareous cement; thin chert seams of Cryptozoon character in the upper portion	15	
2	Concealed	30	
1	Light gray, rather coarsely crystalline dolomite, with some rounded grains of quartz sand, in 6 to 18 inch layers; cement in part calcareous; a thin streak of very black, shaly material near base; frequent, blackish, drusy cavities	30	

This section does not reach the base of the formation, but the lower beds are well shown in the eastern portion of the town with

an additional thickness of some 150 feet. Almost at the base is the shaly zone with Lingulepis acuminata, first reported by Shaler and H. S. Williams.

Though the outcrops are not entirely satisfactory, there is reason to believe that the unconformity at the base of the Tribes Hill limestone locally descends in this vicinity to the top of the ponderous Cryptozoon chert included in bed 9 of the above section. This condition is suggested on the ridge just west of the creek. That the floor on which the Tribes Hill was laid down was uneven is shown by comparison of the two detailed sections made on the north side of the river in the bluffs back of Little Falls. In the section exposed in the creek on the northwest edge of the town, as above described, the Tribes Hill has a thickness of about 50 feet. The silicified Cryptozoon reef of the Little Falls dolomite, which seems to be a persistently marked zone in this vicinity, lies here about 30 feet lower, hence 80 feet beneath the base of the Lowville. Less than 200 feet to the west the 30 foot interval is reduced to about 18 feet. The basal bed of the Tribes Hill (no. 12 of section) also is reduced from 30 feet to about 16 feet. In a branch of this creek about 1/6 mile east, the Cryptozoon bed is only 58 feet beneath the Lowville and only 21 feet beneath the base of the Tribes Hill, which, therefore, is but 37 feet thick at this point. The loss of 13 feet, when compared with the section in the main branch of the creek, is found to be divided between the top and bottom, beds 16 and 17 of that section, aggregating 5 feet, being absent here. The other 8 feet probably are lost from the base, though the character of the middle and lower beds of the Tribes Hill varies rapidly from place to place so that the individual beds are not easily recognizable. A mile farther east, along the road to the quarries northeast of Little Falls, the Tribes Hill seems even thinner, but the exposures are too poor and the dip not sufficiently regular to permit a definite statement on this point.

In mapping the Little Falls sheet it was shown that the dolomite formation rapidly thinned because of overlap, in passing across the quadrangle from south to north. It was at that time supposed to be a single formation, and the loss by overlap was supposed to be at the base. Since, however, we are dealing with two, unconformable formations it may well be that both thin northward because of overlap, and that the Tribes Hill disappears before the Little Falls does, letting the Lowville down upon the latter. Until the quadrangle is restudied it is impossible to definitely pronounce

upon the matter. A study of the section at Middleville, 9 miles northwest of Little Falls, seems, however, to indicate that both formations thin to the north owing to overlap, and that the Tribes Hill pinches out long before the Little Falls does. In the Middleville section the Tribes Hill has apparently disappeared; certainly the fossiliferous, dove limestone beds do not occur. Since the formation still has a thickness of 50 feet at Little Falls and has not been thinning westward from Cranesville at a rate exceeding 2 feet per mile, it is not impossible that this sudden disappearance is attributable to the distance north, rather than the distance west from Little Falls. However, in mentioning the average westerly reduction of the formation it is not to be understood that we regard this as taking place gradually. On the contrary, as intimated in the preceding paragraph, the warping of the underlying surface of Little Falls dolomite renders the suggestion of gradual diminution quite impossible; and the same reason might very well cause rapid thinning west of Little Falls.

At Middleville we measured the following section up the creek which comes into the town from the east:

SECTION AT MIDDLEVILLE

	Feet	Inches
25 Trenton limestone with Dalmanella common in lower 6 feet and Prasopora simulatrix abundant above that	60	
Hiatus	..	....
24 Thin bedded, dove limestone with irregular summit; abundant Phytopsis, and Tetradium cellulosum; typical Lowville	13	
23 Concealed	2	
22 Thin bedded, light colored, sandy limestone with abundant quartz grains; much bored by worms of large size; upper 2 inch layer a calcareous sandstone, at base of which worm tubes cease; 1 foot, 5 inches to	2	2
21 Cobbly, conglomeratic, calcareous sandstone, black to brown in color		10
20 Irregular bed of calcareous, small-pebbled quartz conglomerate; base of Lowville	1	
Hiatus and unconformity	..	....
19 Compact, very fine grained, light bluish gray dolomite	3	

		Feet	Inches
18	Alternating beds of light gray, finely crystalline dolomite and of more sandy, darker colored material; midway is a heavy chert bed, with both black and gray chert	12	
17	An irregular bed of light gray, finely crystalline dolomite, laminated and weathering to finely lined surface, filling irregularities in surface of preceding bed; 1 foot to	3	
16	Very nodular and irregular bed of gray dolomite, with many sand grains and with cherty looking plates of black, silicified sand; 5 feet to	8	
15	Chiefly very light gray, calcareous, sand rock, but with alternating seams of darker colored dolomite.	10	
14	Light bluish gray, finely crystalline, drusy dolomite; very few grains	2	8
13	Very dense, fine grained, light colored, very sandy dolomite, full of rounded grains of quartz sand; many drusy cavities	2	3
12	Porous, very light gray, finely crystalline dolomite, with many sand grains, and frequent green specks; many drusy cavities with quartz crystals in upper portion	3	3
11	Massive, gray dolomite, with many sand grains	5	4
10	Very fine grained, mottled, light gray dolomite	2	6
9	Dark gray, very quartzose, massive dolomite	8	
8	Massive, somewhat porous, dark gray dolomite; sand grains fewer than in the beds beneath, but larger size	12	
7	Light gray, thin bedded, very sandy dolomite, with black streaks running through it; full of sand grains; one thin, hard, fine grained layer 4 feet above base	13	
6	Concealed, about	60	
5	Rather massive, porous, blue gray, crystalline dolomite; frequent crystalline nodules filled chiefly with calcite	4	10
4	Massive, Cryptozoon reef layer; blue gray, porous dolomite with nodules of calcite	5	
3	Blue gray, porous, crystalline dolomite	1	4
2	Concealed, about	25	

		Feet	Inches
1	Massive, finely crystalline to granular, gray dolomite, with large calcite nodules	3	
	Interval to surface of Precambric in West Canada creek, about	50	

In this section, including the concealed interval at the base, we have a thickness of 231 feet of Little Falls dolomite, as measured from the base of the Lowville down to the level of West Canada creek, which is substantially the base of the formation. There is nothing that we could definitely correlate with the Tribes Hill limestone as already stated. The thickness here is just about half the combined thickness of the two formations at Little Falls. Since at least 50 feet have gone from the summit it seems to us clear that the thinning in this direction is not due simply to overlap, but represents a loss both above and beneath; that is that each of the two formations thins northward, and that the Tribes Hill has thinned to the vanishing point.

It will also be noted that there is here a thickness of nearly 19 feet of Lowville and that the Lowville is directly followed by the Plectambonites and Prasopora bed of the Trenton with no sign of the older beds, which in the Mohawk valley have usually been referred partly to the Black River and partly to the Trenton.

Four miles northwest of Middleville along West Canada creek is Newport, and here the most westerly of the good sections, exposing the horizon with which we are especially concerned, is found. The exposures are in the creek bed, the railroad cut just south of the depot and in Dunn's quarry a few rods west of the depot.

SECTION AT NEWPORT

		Feet	Inches
12	Crystalline, highly fossiliferous, gray limestone bands alternating with black argillaceous nodular limestone and a little shale, Plectambonites very abundant; basal Trenton	2	6
	Hiatus	..	....
11	Blocky, nodular, fine grained limestone, black limestone containing Columnaria and Streptelasma; has heretofore been referred to as "Black River" but represents the Leray limestone member of the Lowville formation in Jefferson county	2	2
	Small hiatus	....	....

		Feet	Inches
10	Brittle, dove limestone, of ordinary Lowville character, full of Phytopsis tubes	13	
9	Brittle, dove limestone, with occasional sand grains in the basal layer; slightly impure as shown by irregular laminations on weathered surfaces; Tetradium cellulosum occurs below summit	6	4
8	Concealed except for the surface of one layer at base, which is slightly impure dove limestone, with frequent sand grains	1	9
7	Concealed	3	
6	Thin bedded, light colored sandy limestone and calcareous sandstone; shaly partings; probable base of Lowville	4	6
	Hiatus and unconformity	..	....
5	Concealed	20	
4	Massive, gray, drusy dolomite; quartz sand grains	1	6
3	Irregular, massive to thin bedded, sandy, gray dolomite; many druses above; many sand grains; certain layers mottled and laminated with black	13	
2	Concealed	15	
1	Massive, granular, blue gray dolomite, but few sand grains; Cryptozoon and much chert in lower 5 feet	8	

Here we find the Lowville thickness to exceed 28 feet, as against the 15 feet shown in the Middleville section; we have also beds intervening between the Lowville and the Trenton which do not appear in the Middleville section. But as in that we find no trace of the Tribes Hill formation, the Lowville resting on the Little Falls dolomite.

In these western sections of the Little Falls dolomite, we miss the light colored, coarsely crystalline beds which form the summit of the formation at the east. Whether they were deposited and eroded before the deposition of the Tribes Hill, or whether they change laterally into finer grained, gray beds on passing west, we are not sure. Since the formation shows no diminution in thickness it is perhaps more probable that the latter is the case.

Theresa formation

This name was given by Cushing two years ago to the passage beds and overlying magnesian limestones which occur between the

Potsdam and the Pamelia formation (upper Stones River) in the Thousand Island region.[1] The formation as defined is thin, not over 60 feet, seemed a unit and was thought to be entirely older than the Beekmantown. In its lower portion a variety of Lingulepis acuminata is abundant, while the higher beds contain cystid plates and a large, flat gastropod. These now prove to be identical with the cystid plates and the Pleurotomaria hunterensis (Cleland) which are found in the Tribes Hill limestone of the Mohawk valley, whence it follows that the upper portion of the Theresa formation in Jefferson county is of lower Beekmantown age. We are, however, of the opinion that the lower portion is properly to be classed with the Potsdam beneath as of Saratogan (Ozarkic) age and that there are two formations present instead of one. We also think that an unconformity will be found between the two, now that it is suspected, so that search can be made for it. It is, therefore, unfortunate that a name was given to the supposedly single formation. We suggest, however, the retention of the name Theresa as a designation for the passage beds which occur everywhere in New York between the Potsdam and the overlying Little Falls dolomite, since they have a characteristic lithology of their own, and should be and can be mapped separately.

Correlation of the foregoing sections

In order to bring out more clearly and concisely our ideas in regard to the sections, they are given in generalized form in the accompanying table. The Little Falls dolomite occurs in all and in fairly uniform thickness except at the extreme west where it is thinned by overlap on the Precambric. The Tribes Hill limestone overlies it in most sections, but thins westward to disappearance in the Mohawk valley; the Saratoga region seems to have been just beyond the reach of its deposits. Correlating the Tribes Hill with the typical dove limestone of division B of the Champlain Calciferous, then sedimentation would seem to have been only locally interrupted in that trough as noted in the vicinity of Ticonderoga. But, if the former is older than the latter, as is indicated by faunal evidence, then the whole of the Champlain valley was emerged while the Tribes Hill was being deposited in the Mohawk valley.

The Tribes Hill and Little Falls formations seem everywhere unconformable in New York, and we make this unconformity the

[1] Geol. Soc. Am. Bul. 19: 155–76.

Chart of sections

	NEWPORT MIDDLEVILLE	LITTLE FALLS	SPRAKERS	CRANESVILLE TRIBES HILL BROADALBIN	SARATOGA SPRINGS	WHITEHALL	TICONDEROGA
	Either Lowville, or other Mohawkian limestone caps each section unconformably.						
Ordovicic						Beekmantown Div. D (?C, ?E)	Beekmantown Div. C, D, E
		Tribes Hill limestone	Tribes Hill limestone	Tribes Hill limestone		Unknown	absent or represented in Div. B
Unconformity							
Saratogan	Little Falls dolomite	Little Falls dolomite	Little Falls dolomite	Little Falls dolomite	Little Falls dolomite Hoyt limes.	Little Falls dolomite	Little Falls dolomite
				Theresa formation	Theresa formation	Theresa formation	Theresa formation
				Potsdam sandstone	Potsdam sandstone	Potsdam sandstone	Potsdam sandstone
	Each section rests unconformably on Precambric.						

dividing line between the New York representatives of the Saratogan (Ozarkic) and the Beekmantown (Canadian). In the Champlain region the higher divisions of the Beekmantown occur, but they are utterly lacking in the Mohawk valley and were never deposited there. The Potsdam sandstone and the passage beds (Theresa formation) are also chiefly confined to the eastern sections, though their thinned edges appear in the easterly Mohawk sections. The Chazy is absent in all sections, the Lowville (or some even younger) limestone resting on the Little Falls, the Tribes Hill or on some later division of the Beekmantown, in the various sections included in the table.

Stratigraphic positions of the Potsdam, Little Falls and Tribes Hill formations

Saratogan series. Though the Saratogan was defined and is generally accepted as the name of the closing stage of the Cambric in America, it is now practically certain that the deposits of the series in New York are of a later date than are the formations in Missouri, Texas, Oklahoma, Wyoming and elsewhere, that Walcott and others have referred to the Upper Cambric. While there can be no question concerning the essential equivalence of the beds in the latter states, as indicated by stratigraphic position and persistence of lithologic and faunal characters, the facts are altogether different in the case of the typical New York Saratogan. Practically the same fauna, the species in many cases being identical, occurs in the middle and more western localities in America in beds corresponding to the sandstone and chert beneath the Jordan sandstone of the upper Mississippi valley section. These beds are further distinguished except, in the Great Basin, by the rather abundant presence of glauconitic or chloritic grains and by the almost constant presence of thin limestone conglomerates in their upper parts. Apparently very general sea withdrawal occurred at the close of this Upper Cambric stage. So far as known this Upper Cambric sea is scarcely represented in the Appalachian valley and certainly it did not extend into the middle and northern parts; but it spread widely in the median areas between the Appalachian and Cordilleran troughs.

The return of the waters introduced the proposed Ozarkic period of Ulrich. The new sea differed greatly from the preceding Upper Cambric sea in that it failed to cover the Rocky mountain area and in that it submerged the Appalachian and more

inland troughs and basins to Canada. In the Mississippi valley and in central Texas its deposits covered about the same areas previously held by the late Cambric sea. It is this Ozarkic sea that rather early in its history surrounded the Adirondack uplift, laying down first the Potsdam, then the Theresa and finally, when conditions had become fairly quiescent and established, the Little Falls dolomite. However, long before the close of the Ozarkic the waters were again withdrawn from New York into reconstructed Appalachian troughs, remaining also in the but slightly modified basins of the Mississippi valley.

The more essential features of the evidence on which this interpretation is based may be briefly stated as follows: (1) The stratigraphic relations of the Potsdam to the Theresa and of this to the Little Falls indicate a practically uninterrupted sequence of sedimentation. There was gradual reduction of adjacent land areas, and there may have been slight oscillations, but there is no evidence of a break in deposition nor of change in its character that may not be explained as of purely local significance. (2) So far as known there are no deposits corresponding in age to the Upper Cambric in the Mississippi valley in areas intervening between this valley and the Adirondack region; neither have any been discovered in the middle part of the Appalachian valley nor in the Atlantic province; hence there is no means of directly connecting the Potsdam-Little Falls deposits and faunas with true Upper Cambric life and sediments elsewhere. (3) The Potsdam and Little Falls are clearly recognizable in the Allentown formation (Ulrich) in central and northeastern Pennsylvania and in the lower and middle divisions of the Knox farther south in the Appalachian valley. The Allentown rests on Lower Cambric, both Middle and Upper Cambric being absent in its area. The probably equivalent Conococheague formation of the Cumberland valley in southern Pennsylvania, contains a Saratogan fauna but differs lithologically and is underlain by two Middle Cambric formations. The lower Knox is underlain by a thin Upper Cambric, considerable Middle Cambric and some Lower Cambric, the southern Appalachian Cambric section being relatively complete. Each of these Appalachian Ozarkic formations is overlain by from 1000 feet to 4200 feet of Canadian (emend. Ulrich) limestone and dolomite, represented in eastern New York by the Beekmantown. (4) The fauna so far discovered in the Sara-

togan of New York, particularly in the Hoyt limestone, is entirely distinct from that found beneath the St Lawrence limestone in the upper Mississippi valley, but some of the species occur there in the overlying calcareous and arenaceous deposits (St Lawrence limestone, Jordan sandstone and Oneota dolomite), while all of them are included in the large molluscan and trilobite faunas discovered by Ulrich in the middle divisions of the Ozarkic in Missouri. Most of them occur there in the Gasconade chert, which is the third from the top of the seven formations into which the Ozarkic in Missouri is divisible. All of these formations succeed the Bonneterre limestone and Davis shale, which carry the St Croix and Reagan fauna that is so widely distributed in the Mississippi valley, in the Rocky mountains and in Texas, and which Ulrich, chiefly on diastrophic grounds, regards as marking the closing stage of the Cambric in America. If this is not conceded then there is no sufficient reason for drawing the upper boundary of the Cambric system beneath the top of the Ordovicic — which would go back to Sedgwicks's original conception of his Cambric — nor for recognizing more than a single system in the Neopaleozoic, another in the Mesozoic and a third in the Neozoic. If the Devonic is recognized as a system distinct from the Siluric on the one side and the Waverlyan on the other then the Ozarkic is no less distinct from the preceding "Cambrian" and the succeeding Canadian system; and the Canadian is equally distinct from the Ordovicic. If the criteria relied on are deemed sufficient in any of these instances then they are equally sound and worthy of consideration in all the others.

The boundary between the Cambric and the Ozarkic as here drawn is everywhere recognizable and the contacts between the Ozarkic and the Canadian, and between the Canadian and the Ordovicic are likewise definite. This is because they are determined by diastrophism. But no one has yet succeeded in drawing a satisfactory boundary between the upper limit of the range of "Cambrian" trilobites and the lower limit of the "Ordovician" gastropods and cephalopods. In fact there is no such boundary, since the latter were well established before the middle of the Ozarkic, and Cambric types of trilobites survived through the Ozarkic into the Canadian and a few even into the Ordovicic. Of course, neither the beginning nor the closing deposits of these Eopaleozoic systems are even approxi-

mately similar in geographic distribution. There was too much oscillation for that. Indeed, it is only here and there within the great Appalachian and Cordilleran troughs that anything like a complete sedimentary record of any one of the systems is found. But these inequalities of distribution are an aid rather than a hindrance in the recognition of the boundaries, because they make them correspondingly more distinct where the breaks in the record are expanded.

The faunal distinctions marking the revised systems also are more definite and more readily apparent than are those hitherto relied on in discriminating between the Cambric and the Ordovicic.

In the trilobites and the brachiopods we use specific rather than generic types in discriminating between the Upper Cambric and the Ozarkic; likewise among the previously established conical and involute gastropods. The correlation value and use of such long-lived types is precisely as in the case of genera common to two or more of the later systems in whose discrimination, moreover, specific differences comprise a greater and greater proportion of the competent organic data. The surviving Cambric trilobites and brachiopods have then essentially the same significance in stratigraphic taxonomy that we accord to Spirifer and Atrypa, which are well developed in the Siluric and continued their existence into subsequent periods; or to genera of Ordovicic trilobites that are nearly as well represented in the Siluric.

To disregard the probability of transgressions of generic types from the earliest Paleozoic system into the next younger system is to stand in the way of progress in stratigraphic correlation and classification. The principle is recognized in the discrimination of all the later systems, why not also in the case of the American Cambric? The past practice of classifying, often without regard to stratigraphic evidence, all formations as Upper Cambric that are younger than Middle Cambric and apparently older than beds containing supposedly indubitable Ordovicic fossils, was possibly justifiable, but only so long as the faunal history of a great intervening mass of rocks remained to be accounted for. Now, however, since this old "Calciferous" hiatus has been peopled with a large mixed "Cambrian" and "Ordovician" fauna, and since we have come to understand the stratigraphic relations of most of the formations concerned in the inquiry, some other arrangement that will express the facts is desirable. We need a vehicle that will permit us to cor-

rect the misapprehensions into which the former *terra incognita* and our blind reliance on unsupported fossil evidence led us; a means of showing, for instance, the true stratigraphic relations of the Saratogan fauna as developed in New York to the Upper Cambric faunas in Missouri and Texas, or of the Dictyonema flabelliforme and the Tetragraptus zones, or the Tribes Hill and other Canadian formations to the Saratogan and later Ozarkic formations on the one side and the typical Ordovicic formations on the other. It is believed that the revised classification proposed by Ulrich accomplishes this aim. The table given on page 129, though intended to show only the relations of the New York formations discussed in this paper, gives a fair general idea of the proposed scheme.

Perhaps the most practical feature of the revision of the Eopaleozoic systems, so far as the use of fossils in their separation is concerned, is that we can say that the cephalopods and the coiled gastropods, also true cystids, became prominent for the first time in the Ozarkic, that the true graptolites, true ostracods, true Orthidae and the Asaphidae are first seen in the Canadian, and that the tabulate and rugose corals, the cyclostomatous and cryptostomatous bryozoa, the pelecypods and the crinoids are well developed in the Ordovicic but unknown beneath this system. In short, the new arrangement is in accord with, and makes available in the broader stratigraphic correlations, the apparently definite vertical distribution of many important organic types. This distribution has not been considered as it should be in the prevailing indefinite arrangement of the Eopaleozoic rocks. As hitherto conceived the cephalopods and gastropods, the Asaphidae and Orthidae, and the graptolites appear at undetermined stages in a "Cambrian" system that has no more precise top than the fortuitous first appearance of certain fossil types, arbitrarily assumed to be Postcambric, above a similarly indefinite upper limit of certain Cambric genera of trilobites and brachiopods.

Obviously, there has been no uniformity of practice. Walcott extended the lower system as far up in the section as he could recognize certain Cambric genera. Others, with the laudable but insufficiently considered intention of fixing the boundary at a well defined stratigraphic break, went farther and drew the top of the Cambric at the base of the St Peter, while others with a similar intention extended the base of the Ordovicic down to the first break beneath the introduction of the cephalopods and coiled gastropods, that is to practically the base of the Ozarkic. More commonly,

however, in areas containing Ozarkic and Canadian deposits the boundary between the Cambric and the Ordovicic has been left undecided, or it was drawn arbitrarily in the midst of what was thought to be a great, sparsely fossiliferous, transitional series of dolomites and limestones because its basal part contained surviving remnants of the Cambric fauna, and its uppermost ledges held fossils too much like Ordovicic species to be interpreted otherwise than as Postcambric.

This inharmonious practice was perhaps excusable under the prevailing state of knowledge concerning Eopaleozoic history. So long as the oscillatory character of the continental seas of this era and the consequent variable localization of their deposits were not appreciated, the formations occupying apparently similar stratigraphic positions had to be correlated, and the observed differences in their respective lithologic and faunal aspects were of course only geographic changes or merely local phases. There was also considerable excuse for individual difference of opinion as to which of the organic and physical criteria were the most deserving of confidence.

But now, since it has been learned (1) that the Presaratogan deposits in the Appalachian and Cordilleran troughs attain more than sufficient thickness, and that their diastrophic history in America fully satisfies the requirements of an ideal geologic system;[1] (2) that the great deposits of dolomite, limestone and sandstone which usually succeed the Cambric were not laid down in a continuous broad continental sea, hence that the magnesian limestones at one place may be altogether younger or older than those at another; (3) that these dolomites, limestones and sandstones are divisible or may be grouped into two distinct series, largely independent in geographic distribution and each characterized by its own physical and faunal development; (4) that each of these two series attains an aggregate thickness of over 4000 feet of calcareous deposits, hence, that each is comparable in time value to most of the systems now recognized; (5) that their independence, first suggested by diastrophic and faunal evidence, is now firmly established by the actual superposition of 4200 feet of Canadian dolomite and limestone in central Pennsylvania on fully 2000 feet of Ozarkic deposits; (6) that in the Appalachian region the whole

[1] On questionable grounds, discussed elsewhere by one of the present authors, Schuchert [Geol. Soc. Am. Bul. 20:513–22, 600–2] divides the same interval into two systems (Georgic and Acadic).

of the Canadian underlies an aggregate thickness of nearly 4500 feet of Ordovicic limestone; and finally (7) that essentially the same cycles of movement, of submergence and emergence, as are used in distinguishing four Neopaleozoic systems, also obtained in the Eopaleozoic and suggest the propriety of a similar division of the Eopaleozoic into four systems instead of two as heretofore. In view of these facts we ask: Is the present indefinite separation of the Eopaleozoic into Cambric and Ordovicic a reasonable and adequate classification? Are these divisions coordinate in rank with the Neopaleozoic, Mesozoic and Neozoic systems? Our answer to these questions is clearly anticipated in the foregoing comments and arguments.

Age of the Tribes Hill formation. A few words remain to be added respecting the age of the Tribes Hill. The formation is certainly Postozarkic, but its position in the Canadian is less easily determined. Except that we know the formation to be unconformable on the Little Falls and that the contact represents a considerable hiatus, we have only organic criteria to guide us in determining the age. That the Tribes Hill is younger than any known Ozarkic formation is satisfactorily shown by the presence of Asaphus and three or four other trilobites that are wholly unknown in Ozarkic faunas. The same is true of the Ribeirias; and the Dalmanella? wemplei also is of a type that has not been observed beneath the Canadian. With the exception of Eccyliomphalus multiseptarius, the testimony of the gastropods is less positive, very similar, though specifically distinct, forms being found in Ozarkic faunas. The gastropods described by Cleland from the upper chert zone of the Little Falls dolomite at Little Falls are clearly Ozarkic types and hence are not referred to in this paragraph.

That the Tribes Hill is Canadian (emend. Ulrich) is unquestionably indicated by its fossils; and the same evidence is almost conclusive in assigning the formation to an early stage in this period. With the possible exception of an orthoid shell, all the species so far discovered in the Tribes Hill are distinct from those described from the Beekmantown in the Champlain valley. They impress one as older. This suggestion is confirmed when we compare the Tribes Hill forms with faunas found in the Canadian in central Pennsylvania. The nearest facies — there are at least five and probably six identical species — is found in the Bellefonte, Pa. section about 3700 feet beneath the top of the Canadian. None of the succeeding faunules in the Bellefonte section are closely allied.

Relying on the fossil evidence just given it seems almost certain that the Tribes Hill is at least as old and probably is older than the dove limestone in division B of the Champlain "Calciferous." This conclusion finds further good support in the fact that Cryptozoon steeli, the principal fossil of division B, is found in Pennsylvania *above* the Stonehenge limestone which there contains the Tribes Hill fauna.

Oscillations of level

As detailed work has been carried forward in northern New York during the past few years, the evidence has been steadily accumulating to show that with a possible exception during the late Ordovicic the Adirondack region remained steadily as a land area, being sometimes an island, at other times part of a much larger land. It appears further that frequent and often very local oscillations of level effected modifications of its shore line; that the present erosion surface cuts the rocks in such wise that the surface exposures are chiefly of the thinned, near-shore margins of many of the formations; that gaps in the succession are frequent, and with much variation from place to place; and that, because of these conditions, the New York section of these rocks is very thin and very imperfect. From time to time Cushing has summarized our knowledge of these oscillations.[1] With each onward step in the detailed work, however, evidence of further, and unexpected oscillations appears; and no doubt we are, even now, acquainted with but a small proportion of them. Nevertheless our present understanding of them should be summarized.

To begin with, no part of New York was submerged during the Cambric. Lower Cambric deposits do occur locally within the eastern edge of the State south of the Champlain valley but it is highly probable that these are masses originally laid down in a trough farther east and which were subsequently thrust westward to their present position. The somewhat doubtful Middle Cambric sediments found in Stissing mountain near Poughkeepsie probably owe their present location to similar thrusting. True Upper Cambric (St. Croixan) rocks are entirely unknown within the State. Neither have such been found to the

[1] N. Y. State Mus. Bul. 77, p. 51–65.
N. Y. State Mus. Bul. 95, p. 386–94.
Geol. Soc. Am. Bul. 19:175–76.

east in the New England States, nor to the west as far as Michigan and Indiana. They seem to be absent also in the Appalachian folds north of Virginia. Evidently New York formed part of a very large land area during the Cambric ages. The first important and unquestionable Paleozoic submergence of the southern flanks of this land occurred in the early part of the succeeding Ozarkic period. This was the Potsdam or Saratogan submergence.

Potsdam deposition commenced in the Champlain trough, toward its northern end, working southward in that trough, and also working westward up the St Lawrence trough. In its lower portion it was probably a continental deposit, but the upper portion carries a marine fauna, and this continues on through the passage beds into the Little Falls dolomite which lies directly above. The deposition was continuous and unbroken, so far as we know, from the one formation into the other. The subsidence in the St Lawrence trough reached as far west as Kingston during the Potsdam and probably but little farther. From Kingston it extended southward at least to some point in the valley of Black river. To how large an extent western New York was submerged we do not know positively. It seems likely, however, that a considerable expansion of the upper St Lawrence trough occupied the north central part of the State and probably covered also the western part of New York and the central part of Pennsylvania. For various reasons which can not be discussed at this time, it seems unlikely that this western lobe of the Saratoga sea connected with the eastern or Champlain lobe across the southern part of New York prior to the closing stage of the Potsdam. In this and the transition stage the highly emergent parts of the Adirondack uplift which now became an island, had been much reduced by erosion and general subsidence; and the supply of clastic matter consequently was much less during the succeeding Little Falls dolomite stage. However, just preceding the latter, warping occurred which caused reemergence of the northern and western flanks of the island and restriction of the sea to the Champlain trough on the east and the Mohawk basin on the south. The latter extended southward to northern New Jersey where its deposits are recognized in the lower part of the Kittatiny dolomite; and thence in a southwesterly direction through central Pennsylvania. Gastropod faunas found at Beauharnois near Montreal, near White-

hall, N. Y., in central Pennsylvania and in northern Virginia, leave little doubt that this sea extended down the western side of the Appalachian valley to the Mississippi valley where the same species are found in the middle formations of the Ozarkic system.

A thinned edge of the upper Potsdam runs westward into the Mohawk valley, but thins out to zero rather rapidly, letting the Little Falls dolomite down on the Precambric. It is thought that along the Mohawk line the Potsdam shore had a southwesterly trend, or rather a trend more to the south than the present Precambric margin, the two meeting at an angle; east of the meeting point the Potsdam appears underneath the Little Falls, while west of it the Potsdam is either absent or erosion has not yet cut down to it. This involves the assumption that the Little Falls subsidence covered more of the southern part of the old land area than did the Potsdam, so that, within the Potsdam zone there would be a strip of territory with the Little Falls resting on the Precambric. In some localities there is direct evidence that this actually occurred, and it was likely true of much of the southern and eastern parts of the Adirondack border.

In the Thousand islands region we find merely the thinned edges of the marine Potsdam and Theresa formations with no sign of the Little Falls dolomite. However, since these were laid down in the extreme westerly portion of the St Lawrence trough it is theoretically possible that their deposition occurred while the dolomite was being deposited along the Champlain and Mohawk lines. But there is no positive evidence that such a condition obtained. On the contrary, according to the trend of the scant faunal evidence and the probabilities suggested by general disastrophic considerations the lower or typical Theresa on the west flank of the Adirondacks is essentially contemporaneous with the transition beds on the east side; and deposition was prohibited by emergence on the west side when the Little Falls was being laid down in the Champlain and Mohawk valleys.

Following the Little Falls deposit, warping and differential uplift ensued, causing the shore lines to retreat from the district and resulting in the unconformity at the top of the Little Falls. There was some wear also since the summit is uneven and the Tribes Hill rests on different beds of the Little Falls; and, the returning waters assumed a different arrangement, with a more diversified shore line.

Beekmantown depression commenced with the Tribes Hill de-

posit, which nearly everywhere in the Mohawk valley rests on the Little Falls. In the Black river valley, where the Little Falls is absent, it rests on the Theresa formation. It is absent at Middleville and Newport, in the West Canada creek valley, showing that there, at least, it did not extend as far northward on the Adirondack oldland, as the Little Falls did. It is absent also at Saratoga, indicating that there also we are beyond its shore line. The exact equivalent of the Tribes Hill seems not to occur in the Champlain valley. At any rate its peculiar fauna has not been observed there. Apparently it is older than the fine grained limestone of division B with which the revised Beekmantown begins in the Champlain valley. Judging from the evidence now available the Tribes Hill submergence formed a geographic pattern quite different from that of the preceding Little Falls sea. The latter covered the southern and eastern flanks, the Tribes Hill occupied more limited embayments on the southern and western sides of the Adirondack area. The depression at the west was short-lived, uplift following with increasing eastward tilting, giving rise to long continued submergence of the Champlain valley. By the close of Tribes Hill time the uplift involved all the Mohawk region proper, the remaining divisions of the Beekmantown limestone being confined to the Champlain valley trough and its northern and southern prolongations. The upper Beekmantown is found to the north in the Ottawa valley. To the south Beekmantown deposits are recognized at intervals through southeastern New York, New Jersey and Pennsylvania. Although the Beekmantown is of extraordinary thickness in the last state (2000 to 4200 feet) even the thickest sections still indicate occasional interruptions in sedimentation and probably withdrawal of seas.

At the close of the Beekmantown uplift again occurred, producing the unconformity between it and the Chazy, in the Champlain valley.

We have evidence also of a number of hitherto unsuspected oscillations of the general region during the succeeding Black River and Trenton times. Since, however, we are here concerned chiefly with the lower formations, those are left for discussion elsewhere.

ON THE SYMMETRIC ARRANGEMENT IN THE ELEMENTS OF THE PALEOZOIC PLATFORM OF NORTH AMERICA[1]

BY RUDOLF RUEDEMANN

We wish to present certain facts indicating that the structural development of eastern North America has taken place in such a fashion that a notable symmetric arrangement of its elements has resulted.

This arrangement becomes especially distinct when the large area of Paleozoic rocks extending from the Canadian protaxis southward is considered by itself. This area, which is roughly bounded on the west by a line connecting the head of Lake Superior with the Ozarks and on the east by a line inclosing the Adirondacks and Appalachia, we may for convenience term the *Paleozoic platform of North America.* It corresponds in its relation to the Canadian shield with that of the "Russian platform" of the European geologists to the Baltic shield. A glance at the geologic map of North America will show that this platform is a direct southward continuation of the Canadian shield or protaxis and bounded by southward converging lines that are direct continuations of the boundaries of that shield[2] [*see* chart II, where the line M-N indicates the southern boundary of the Canadian shield A], as described by Suess and Willis. In the west the platform, like the Canadian shield, is separated from the Rocky mountain area by the north-south transcontinental depression that extends from the Gulf of Mexico to the mouth of the Mackenzie river and is occupied by Cretaceous and Tertiary rocks.

Chart II shows that the Canadian shield and its Paleozoic platform together form a body strikingly similar in its outlines to the whole continent, a fact that can not but suggest that the "Leitlinien" of this large epeirogenic element and the whole continent stand in genetic relationship.

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[1] Submitted April 1909.

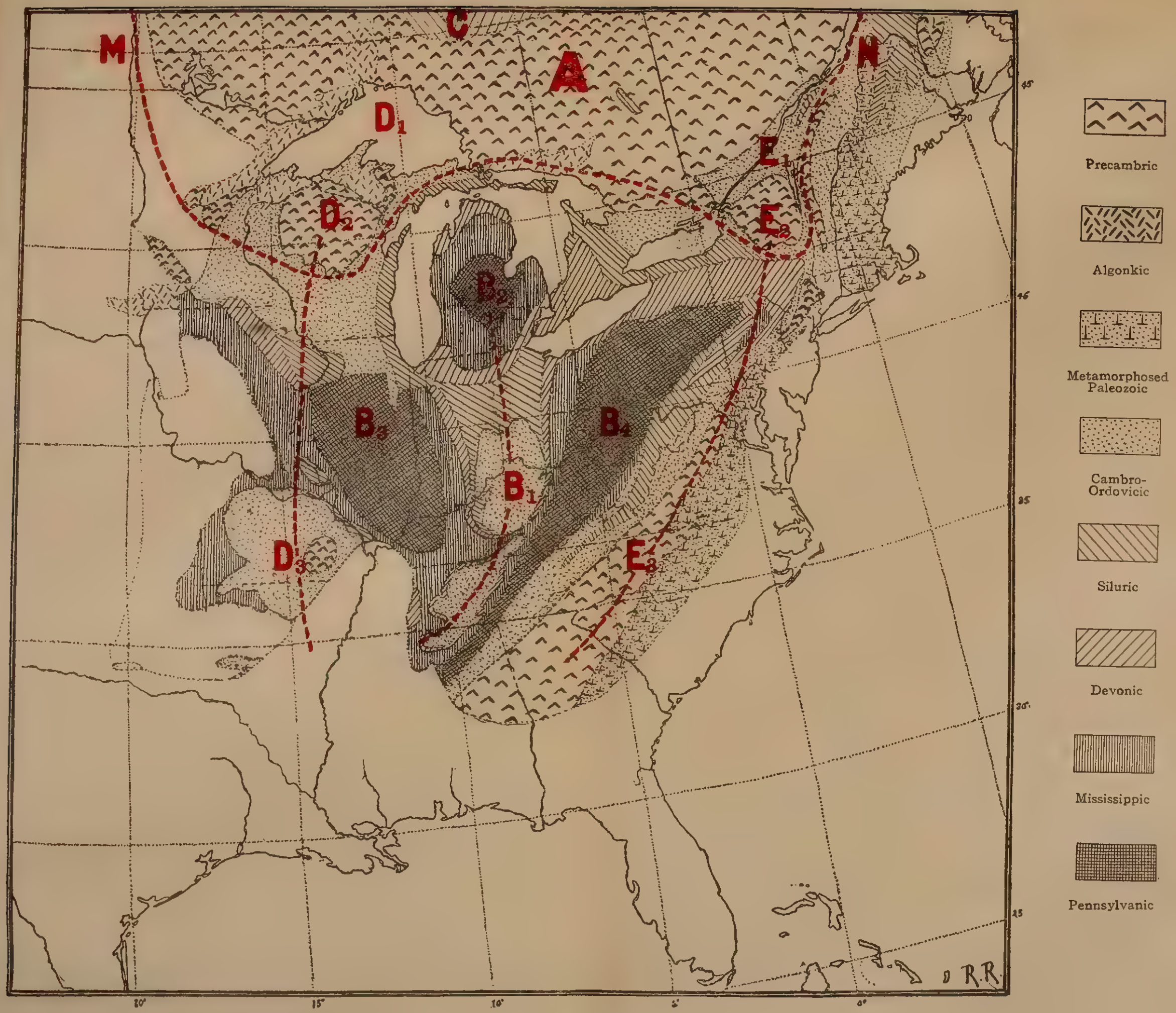
[2] The Mesozoic and Cenozoic embayment of the Mississippi Valley is, in this discussion, left out of consideration, because of younger age; likewise the belt of Carbonic rocks to the west and southwest of the Ozarks, that forms the outer slope of the western arm of the platform, roughly corresponding to the area of metamorphic rocks on the opposite slope of the other arm, and properly belonging to the transcontinental depression.

In comparing the sketch map, chart I with the diagram [chart III] in which separate shading brings out the elevated and depressed regions, it is seen that on either side of the Canadian shield or protaxis [A], there stand out, like cornerstones, two separate Precambric areas, the Isle Wisconsin [D_2] and the Isle Adirondack [E_2] in quite symmetric positions. Each has its extension connecting it with the protaxis in symmetric position, that of the Isle Wisconsin being directed northeast (partly submerged by Lake Superior), that of the Isle Adirondack northwest. From each of these extensions there runs outward, along the margin of the shield, a deep depression, the Lake Superior basin [D_1] and the St Lawrence basin [E_1]. The latter is less distinct through the disturbing influence of the Appalachian folding and probably much obscured by extensive overthrusting from the southeast along "Logan's line." The effect of Appalachian folding by crushing in one side of the symmetric structure here set forth, will be discussed more fully in another chapter [*see* p. 145.]

From each of these cornerstones there extends southward like an arm, a broad belt of Precambric and early Paleozoic rocks, nearly the full length of the continent. The western arm can be traced by the great southward extension of the Precarbonic rocks of Isle Wisconsin to near the neighborhood of Burlington, the Siluro-Devonic inlier along the Mississippi above its junction with the Missouri and the large Precambric-Cambro-Siluric inlier or uplift of the Ozarks in Missouri and Arkansas[1] [D_3]. Its "Leitlinie" is shown in red overprint in the line passing from D_2 through D_3. The eastern arm [E_2–E_3] has been badly overridden, broken up and forced inward by the tangential pressure that has produced the Appalachian folds. It is, nevertheless, still easily recognized in the belt of Precambric and Precarbonic rocks, extending south and southwestward from New York as far as Alabama.

The two arms have later been somewhat disturbed and obscured, especially the western one, by the breaking down of certain portions south of Isle Wisconsin, where the Carbonic

[1] The Ouachita mountains in Arkansas probably represent, according to Dr Ulrich's description [in Preliminary List of Papers, Am. Geol. Soc. 21 Meet. 1908, p. 21] and as already indicated by their strike, a different element and will, for this reason, be left out of the discussion for the present.



GEOLOGICAL SKETCH MAP OF THE EASTERN UNITED STATES

MN southern boundary of Canadian shield A. D_2 and E_2 the symmetric Isles Wisconsin and Adirondack. D_1 and E_1 the adjoining marginal depressions of the shield. D_2-D_3 guide line of western arm of platform. E_2-E_3 that of the eastern arm. D_3 Isle Ozark. E_3 Isle Appalachia. B_1-B_2 guide line of axis of eastern basin. B_1 Cincinnati geanticline. B_2 Michigan basin. B_3 and B_4 symmetric subbasins

has transgressed it, and the eastern one by the submergence of portions southeast of the Adirondacks and by extensive folding. In their original position the two arms may be conceived as approaching each other somewhat in the south, although not nearly so much as they do now, in consequence of the forcing inward of the eastern arm, for if the considerable shortening of the Eastern basin indicated by the Appalachian folds, is taken into account and the basin spread out to its original width, the eastern arm would probably take a position fully corresponding to that of the western.

These two arms bound a large basin [B of chart II], the "Paleozoic eastern basin," now occupied by the basin of Ohio and the Great Lakes. In the middle of this an elongated low elevation formed, now indicated by the Cincinnati and Nashville "uplift."

The axial position of this uplift [*see line* B_2–B_1 on chart I] suggests that it may partake of the nature of the "geaniticlinal median"[1] that according to Haug[2] forms along the median line of a geosyncline preparatory to more extensive folding. The southern portion of the uplift which according to its normal position to the basin and the Precambric arms, should extend due south, has been affected by the Appalachian folding and twisted into a southwest direction. As a result of the warping of the axis of the basin, two separate symmetric basins have been formed,[3] one, the Eastern Interior, and the other, the East Central basin. On account of the approach of the Precambric arms in the south, these basins do not extend north and south, but extend symmetrically to northwest and northeast. The Ohio river from the Pennsylvania to the West Virginia line flows along the axis of the eastern basin.

The northern portion of the Paleozoic platform that lies to the north of the Cincinnati geanticline assumed the aspect of a separate subcircular basin, typically indicated by the Michigan coal field and the locations of Lake Michigan and Lake Huron. It also

[1] Dana clearly recognized this uplift as a geanticline.

[2] Haug, Émile. Soc. Géol. Fr. Bul. 28, ser. 3. 1900. p. 617, and *id.* Traité de Géologie I. 1907. p. 164.

[3] Dana [Areas of Continental Progress in North America, etc., Geol. Soc. Am. Bul. 1890. 1:41], recognizing the importance of the regions of shallow seas represented by the Cincinnati uplift and the Precambric region of Missouri as regards rock-making, has distinguished these basins by the terms here used.

lies symmetric to the whole arrangement and with the Cincinnati uplift it is on the line of symmetry. It is possible that this Michigan basin, instead of being an independent depression, originated from the same warping force as the Cincinnati uplift, being the result of a longitudinal oscillation of the axis of the same geanticline, comparable to those more intensive longitudinal oscillations of the axes, which have been observed in some of the Alpine folds [*see* Haug, Traité p. 211]. The Canadian geologists, however, have claimed to find the influence of the Cincinnati uplift extending from the west end of Lake Erie further north to Lake Huron. In this case it would seem that the Atlantic pressure had affected the entire extent of the uplift [*see* p. 145] giving it a direction subparallel to the Appalachian folds, and the Michigan basin would have to be considered as independent of the Cincinnati uplift, a view distinctly not supported by the general distribution of the formations around the basin.

The development of these symmetric structures may have taken place as shown in charts II and III. In chart II the Canadian shield A and its Paleozoic platform are outlined, the two separated by the line M-N. First then, an extensive depression affected the middle portion of the platform producing the Paleozoic eastern basin B, and leaving two long embracing arms standing, the western one D and the eastern one E. A slight depression had also taken place in the northern slope [C] which finds its expression in the Hudson Bay embayment. Since this and the eastern basin lie with their longitudinal axes on the same line (meridian), the idea that they may be expressions of the same warping movement, is worthy of some consideration. In its favor could be mentioned the fact that a path of migration is postulated along this line for the Niagaran fauna by Weller and a Devonic embayment by Schuchert. It will be noticed [*see* chart II] that the Hudson Bay Devonic embayment [C] and the Michigan basin approach so much that only a relatively narrow Precambric belt separates them, upon which, moreover, still a small Paleozoic outlier (n.e. of Georgian bay) remains. It is therefore quite probable that temporary depressions extended there across the protaxis, and that the resulting Siluric and Devonic rocks have disappeared again by erosion.

Chart III illustrates the changes which next took place in the two arms and in the inclosed basin. The arms were broken

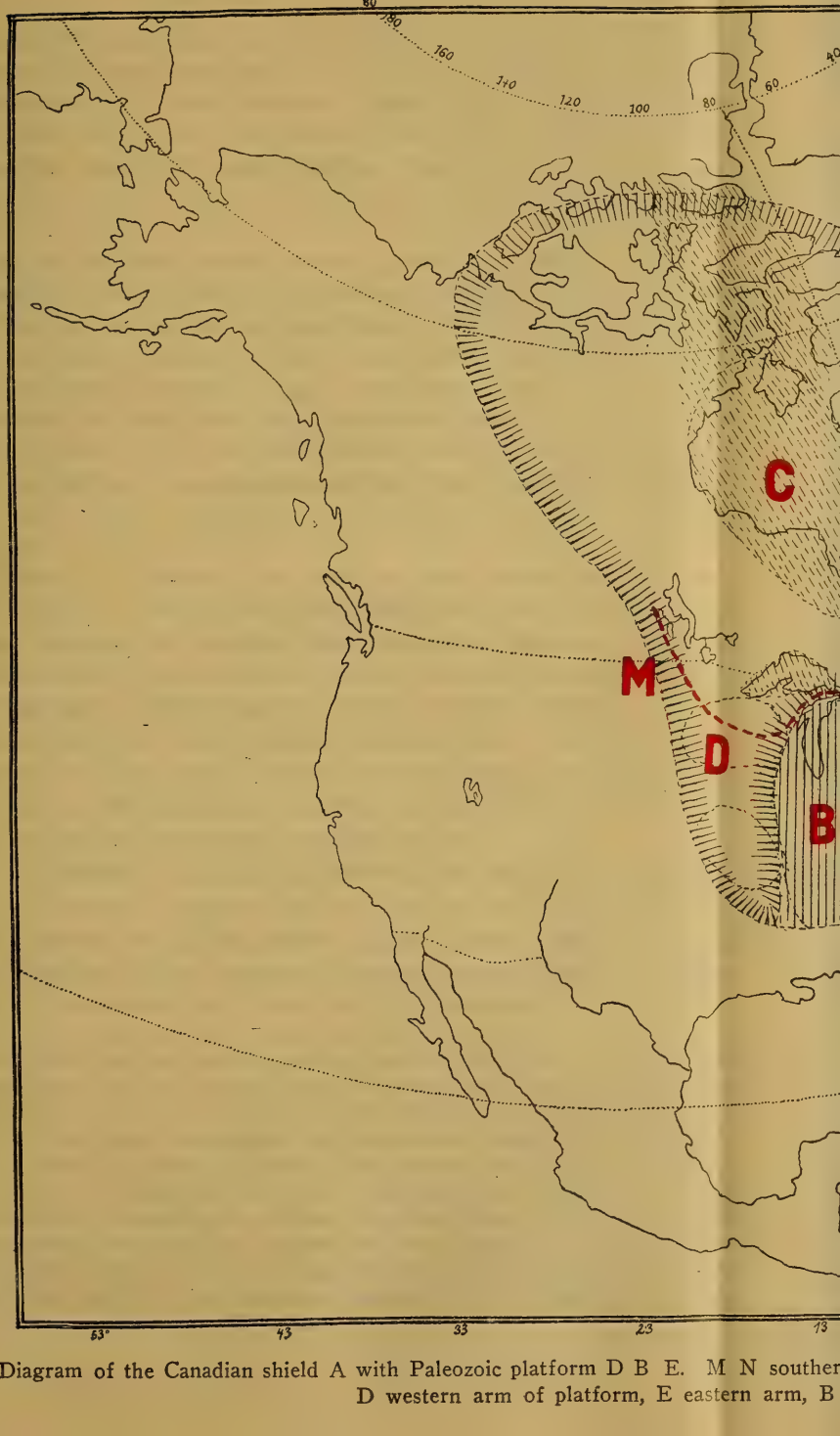


Diagram of the Canadian shield A with Paleozoic platform D B E. M N souther
D western arm of platform, E eastern arm, B

Chart 2

Diagram of the Canadian shield A with Paleozoic platform D B E. M N southern boundary of shield. C Hudson embayment. D western arm of platform, E eastern arm, B inclosed basin

up, with the result that on either side two principal isles, Isle Wisconsin [D_2] and Isle Ozark [D_3], Isle Adirondack [E_2] and Isle Appalachia [E_3] were formed. These isles are distinctly paired. On either side between the Canadian shield and the first isle a depression formed, the Lake Superior basin [D_1] and the St Lawrence basin [E_1], and other depressions between the first and second isles.

In the Paleozoic eastern basin a broad low anticline, the Cincinnati-Nashville parma [B_1] arose,[1] exactly in the axial line of the depression and in continuation of this line of elevation the northern part of the basin sank down into an axial basin, the Michigan subbasin [B_2]. On either side of the parma, between the latter and the Precambric arms, two basins, the East Central [B_3] and the Eastern Interior basin [B_4] were formed, in such an arrangement that they converge southward and are exactly symmetrical to the axial line of the eastern basin.

Chart IV illustrates the effect of the sub-Atlantic pressure, the cause of the Appalachian folding and overthrusting. This stress crushed or crumbled this symmetric structure from the southeast, its influence being felt in the whole eastern portion of the area. Following Claypole's earlier estimates, Willis, [Geol. Soc. Bul. 1907, 18:404] remarks that "it is a moderate statement to say that during the Appalachian revolution that portion of the continent southeast of the Cumberland Plateau rim moved northwestward at least 50 miles."[2]

On account of its oblique direction to the north-south axis of the Paleozoic eastern basin, the stress reaches deepest into the latter in the south, where it has clearly turned the Nashville portion of the Cincinnati-Nashville parma aside. It further

[1] Suess has termed such broad warpings "parmas."

[2] Dr Willis arrives at this estimate in the following way: It is well established that the folding of the Paleozoic strata in the Appalachian zone corresponds to a narrowing of the zone by 35 miles or more — that is, the Blue ridge approached the Cumberland plateau from a distance of 100 miles to within 65 miles. The general effect may best be described as a composite overthrust from southeast toward northwest. Keith's recent investigations show that overthrusts of equal or greater displacement traverse the gneisses of the Smoky mountains. Hence it is a moderate statement to say that during the Appalachian revolution that portion of the continent southeast of the Cumberland Plateau rim moved northwestward at least 50 miles.

lengthened the Eastern Interior basin, and extended it into southeastern New York, or considerably farther north than the opposite East Central basin. Moreover, it may have produced secondary depressions east of the Michigan basin, which have finally found expression in Lakes Erie and Ontario. The principal facts suggesting the latter view are the general parallelism of these lake basins with that portion of the Appalachian folds southeast of them [1] whence the push came. It should, however, in this connection be taken in account, that it can have been but the last stages of Appalachian folding that produced the gentle down-warping of these basins, since the outwardly convex strike of the earlier Paleozoic formations (best seen at the west end of Lake Ontario) shows that this was an elevated region until at least Devonic time. It is therefore quite possible that these depressions are the counterparts of the late (early Tertiary) domelike warpings in western Pennyslvania [2] and southern New York, to which their longitudinal direction clearly corresponds.

The joining of the Appalachian folds that die out in southern New York by a new north-south system of folds in eastern New York, brings the folded region close against the Adirondack isle and produces another depressed "Vorland," the Champlain basin. The Ottawa-Montreal basin that corresponds in its position and also in its form, in surrounding the north side of the Adirondack isle, to the Lake Superior basin, has also been much encroached upon by the westward pressure of the folded region and no doubt to no little amount by extensive overthrust.

It will be seen that with the conception here presented of the geologic development of the eastern United States, the Great Lakes fall, by the first impetus to the formation of their basins — omitting the later accessory agencies, as glaciation and preglacial drainage-lines — into three groups, viz:

a Lake Superior, originating from the breaking down of one of the arms of the Canadian shield.[3]

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[1] By drawing a straight line connecting the folds from the Tennessee-Virginia line to the Pennsylvania-New Jersey line, one obtains a line that indicates the general direction of this portion of the folds, and that line is parallel to the two lake basins.

[2] *See* Campbell, M. B. Geol. Soc. Am. Bul. 1903. 14:277.

[3] The Lake Superior basin clearly antedates all the others, at least with its western arm which rests in Algonkian rocks that indicate a very early depression in the Canadian shield.

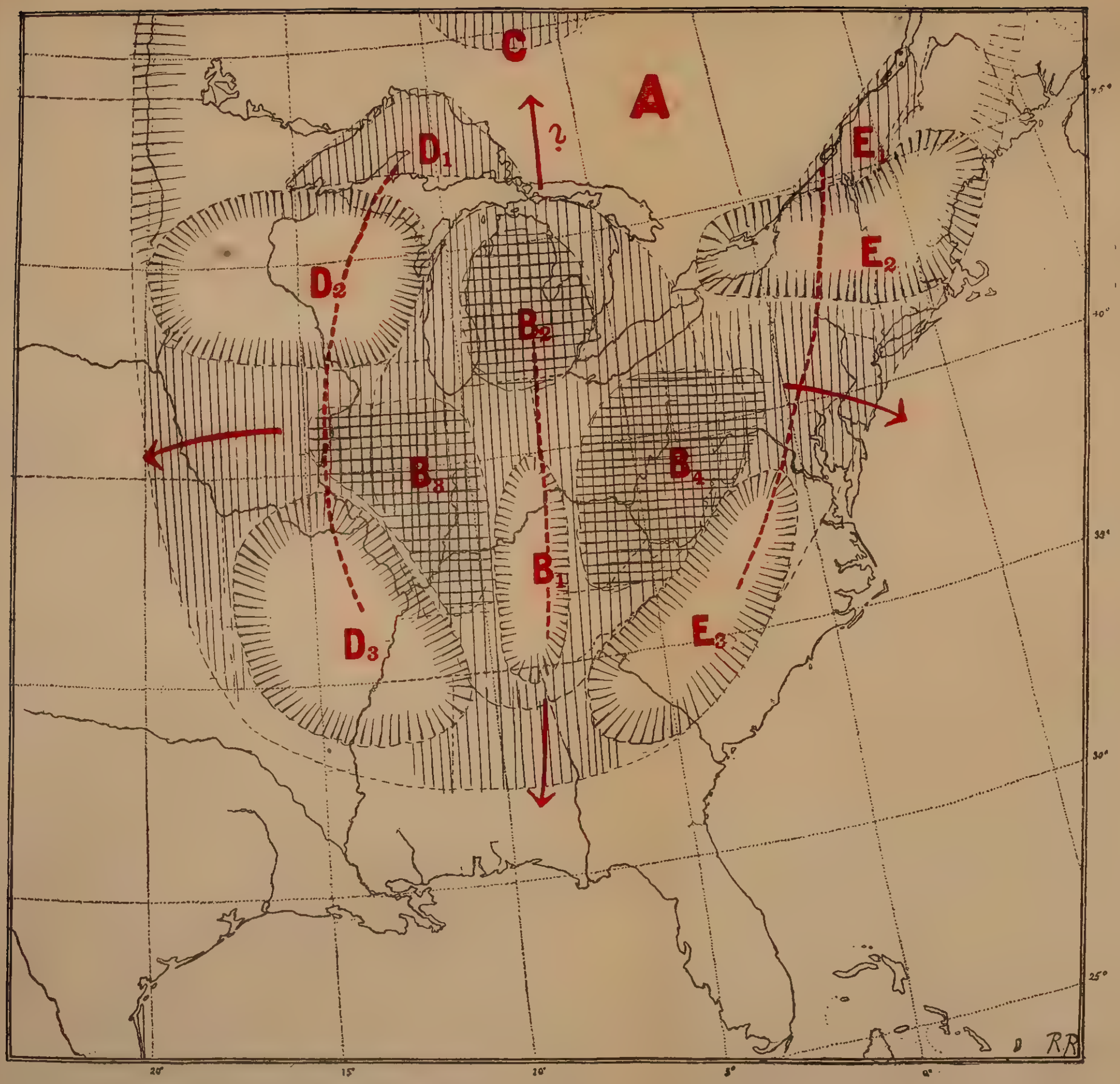


Diagram to show events on southern slope of North America still without interference of Atlantic pressure. Lettering as on chart 1. Arrows indicate main outlets of basin B.

b Lake Michigan and Lake Huron. Their location and form correspond to the Michigan basin, where they roughly follow the Devonic belts.

c Lake Erie and Lake Ontario, either depressions originating from the action of the Atlantic tangential pressure, or counterparts of later warpings in the upper Ohio basin and western New York.

We have thus far left out of consideration the Appalachian basin or "geosyncline" which occupies a narrow strip on the west side of Appalachia [chart IV] and is continued northward through New York and Vermont into Canada. It has later become the site of the Appalachian folds. Ulrich and Schuchert[1] have clearly shown that this basin became early subdivided by longitudinal and transverse barriers into a number of smaller basins. In their directions these barriers foreshadow the later, more intensive Appalachian folding, and are early indications of the influence of the pressure acting from the Atlantic basin upon and through Appalachia. It is certain that the Appalachian basin itself which became the site of the intense folding resulted from the Atlantic pressure upon Appalachia, due to suboceanic spread. It is therefore a foreign element, so to say, in the geologic history of the Palezoic platform which, however, has strongly obscured the original symmetry of the latter. While all changes here noted on the platform are of epeirogenic character, the Appalachian folds are an orogenic feature.

While in general the isles have emerged in Paleozoic times and the basins have been submerged, there have been continuous changes in the amount of emergence and submergence. This fact becomes especially manifest through Professor Schuchert's paleogeographic maps, as far as they have appeared in print, and it is probable that these subsidences and elevations took place in rhythmic pulsations.

With all these continuous changes, however, the sum total of the elevations of isle Wisconsin, isle Adirondack, Ozarkia and Appalachia has been greater than that of the depressions and they represent, therefore, positive elements of the continent in the sense used by Willis[2] while the depressions are negative elements in which, however, in some zones, as in the Cincinnati uplift, the algebraic sum of the unconformities and sediments may approach zero. The most conspicuous negative element is the Appalachian basin with its immense sedimentation.

[1] N. Y. State Mus. Bul. 52. 1901. p. 633.

[2] Willis, Bailey. Geol. Soc. Am. Bul. 1907. 18:389.

The symmetry of arrangement of the platform is likewise but a surplus of symmetric features in the general structure over many asymmetric details in the different stages through which the platform has passed. This again is well shown by the charts of Professor Schuchert. It will be seen that at times the Nashville uplift was joined to Appalachia, and the Eastern Interior basin moved northward, while the East Central basin was divided by a secondary peninsula (Kankakee) and Ozarkia joined to a vast western tract. But at the same time the two arms of the platform with their northern isles Wisconsin and Adirondack (as peninsulas) and the southern land bodies of Ozarkia and Appalachia remained distinct elements and likewise the Mediterranean basin remained defined in its general outline.

The main outlets from the Paleozoic [*see* chart III] passed eastward between the Isle Adirondack and Appalachia and westward between Isle Wisconsin and the Ozark uplift and southward between Ozarkia and Appalachia. The Wisconsin and Adirondack isles have apparently been frequently attached to the protaxis. This becomes especially manifest in the case of the Adirondack isle, where the Beekmantown, Pamelia, Chazy, Lowville and probably also Black River formations do not cross the connecting Frontenac axis. The St Lawrence depression, however, frequently became an important highway of migration (as in Beekmantown, Onondaga and Hamilton times) through its southward connection, by different straits, at different times with depressions between the Isle Adirondack and Appalachia [*see p. e.* Schuchert's map of Onondaga time].

There are facts available that indicate approximately the time when the symmetric arrangement of the Paleozoic platform took place. As we have noted before, Algonkian sedimentation took place around Lake Superior [*see* chart I] but aside from this somewhat independent depression, the whole platform was, according to Walcott's investigations,[1] above sea level until Upper Cambric time, with the exception of the Appalachian geosyncline. The relation of the Upper Cambric deposits to the Isles Wisconsin and Adirondack would indicate that in this period the separation of the Paleozoic eastern basin and of the inclosing arms, took place and probably also the beginning of the breaking up of the arms. The Isles Wisconsin and Adirondack, Ozarkia and Appalachia have

[1] *See* pl. 2, 3 of Walcott, U. S. Geol. Sur. Bul. 81, 1891.

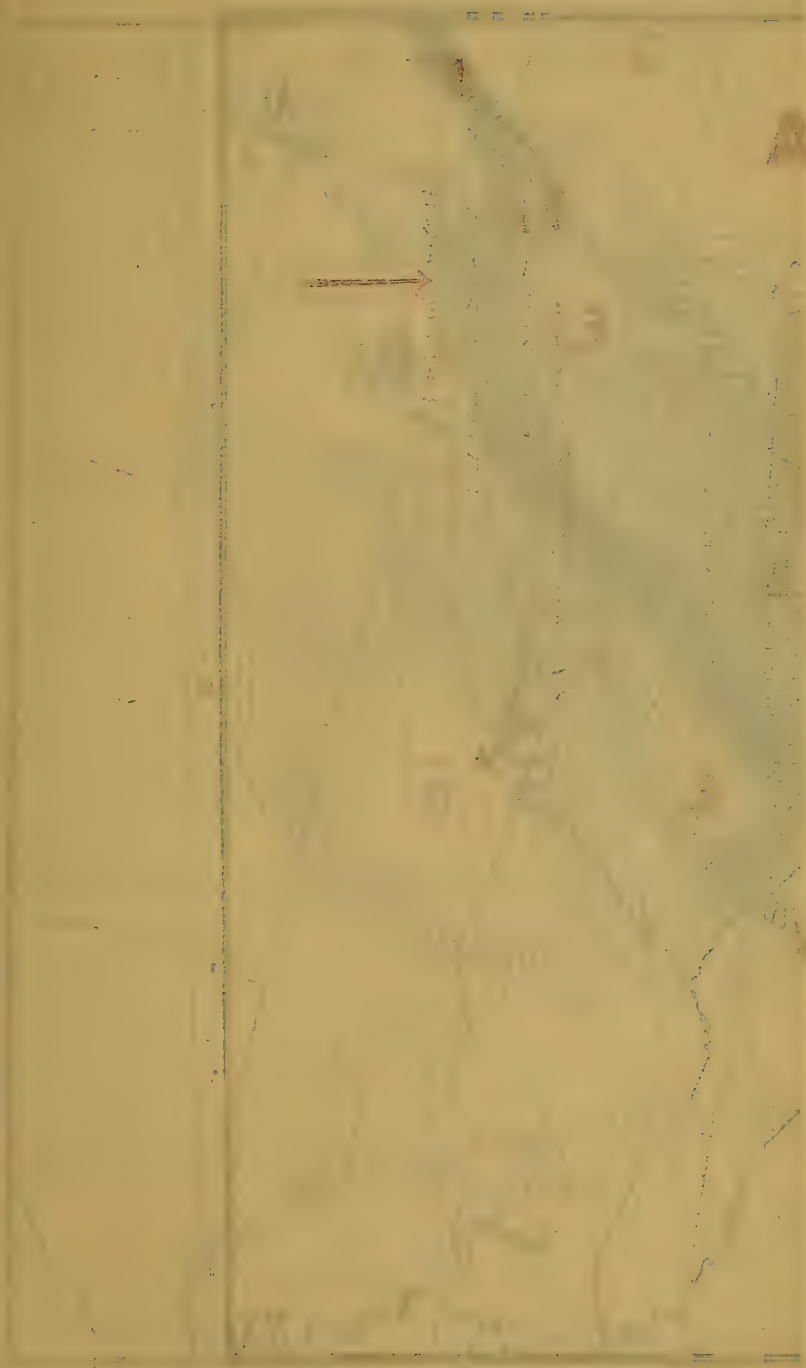


Chart 4

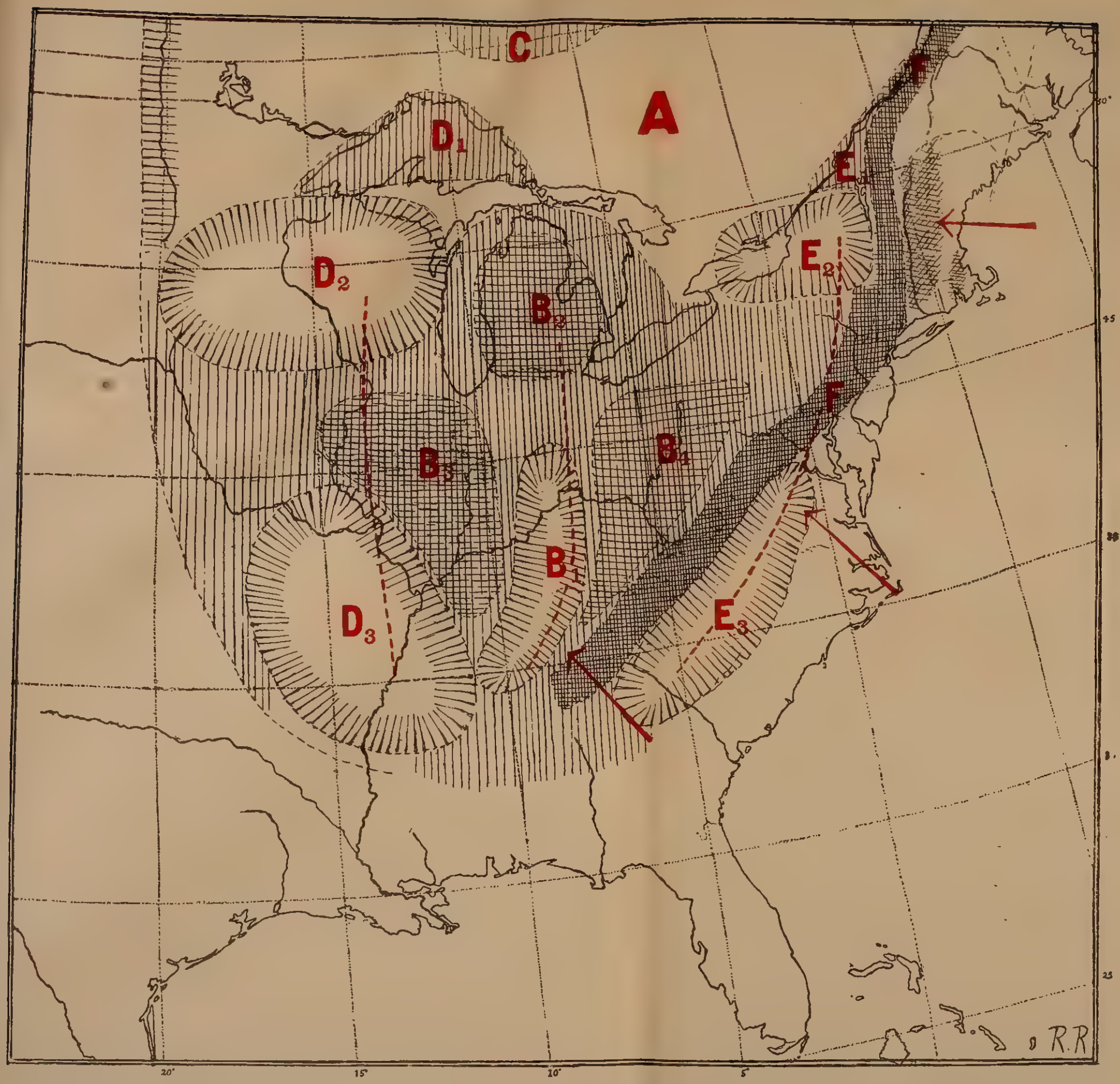


Diagram to show results of Atlantic pressure (indicated by arrows) on eastern arm E_2-E_3, subbasin B_4 and geanticline B_1.
F belt of folding through Atlantic pressure

remained above the sea since the end of the Lower Siluric. In Upper Siluric time the Cincinnati parma had become a prominent feature, although the Cincinnati and Nashville parts of the same were again separated repeatedly, as in Hamilton and Mississippian times, by the submergence of the middle part. In Carbonic (Mississippian and Pennsylvanian) times all the subdivisions of the platform distinguished above, were fully developed. Since then the platform has remained land, with the exception of the Mesozoic Mississippi embayment.

Summary

The writer endeavors to point out:

1 That the Paleozoic platform of North America extending south from the Canadian shield, forms, together with the latter, a structural element of the continent, that is similar in outline to the latter.

2 That the Paleozoic platform exhibits a symmetric arrangement of its parts. This symmetric arrangement consists in the presence of a median basin (Paleozoic eastern basin) that is flanked on both sides by broad elevations, extending southward from the Isles Wisconsin and Adirondack which possess symmetric positions with reference to the Canadian shield. Ozarkia and Appalachia, the two remaining portions of elevations, hold like symmetric positions.

3 The axial line of the Paleozoic eastern basin is occupied by the Cincinnati-Nashville parma and the Michigan subbasin. The former divides the Paleozoic eastern basin into two similar and symmetric basins, the Eastern Interior and East Central basins.

4 The disturbing factor has been the Atlantic pressure, which pushed the eastern arm in and produced the Appalachian basin folds, its effect reaching as far as the Nashville uplift.

ORIGIN OF COLOR IN THE VERNON SHALE

BY W. J. MILLER

For over 50 years the subject of the origin of colors in rock formations has been much discussed and many explanations have been offered. Of the early papers that by Maw[1] in 1868 is perhaps the most able and comprehensive. In 1879 Julien[2] published a paper which contains a discussion of the origin of red formations. In 1899 Russell[3] ably treated the subject of subaerial rock decay and color origin in certain rocks. His paper gives a good summary of the views expressed by earlier writers. In 1908 Barrell[4] gave an excellent discussion of the origin of such colors in rocks. It is not the purpose of the present brief paper to deal with the phenomena of colors in rock formations in general nor to review the literature, but it is rather to confine attention to the color phenomena of the well known Vernon red shale of central New York. That the color phenomena in these shales are not merely superficial or due to recent atmospheric action, is proved by the fact that the same features have been found in deep wells passing through the formation.

The Vernon shale has its type locality in the town of Vernon, a few miles west of Clinton, and it extends from southern Herkimer county westward across the State. Wherever exposed the shale presents a striking appearance due to its red color. A section, including the Vernon shales, near Clinton is as follows in descending order:

3 Camillus formation — Dark, thin-bedded shales

2 Vernon formation — (150 feet).
- *c* 5 feet of light green shale
- *b* 135 feet of dull red shale, unstratified and with green spots scattered through the mass
- *a* 10 feet of light green shale

1 Niagara formation — Dark shales and sandy limestones. Contains large concretions.

The red shale, with the green bed at its base, is well shown in the ravine just north of Hamilton College and in Kirkland glen nearly 2 miles southwest of Clinton. The upper green bed, with the Camillus above and the red shale below, are well exposed at the reservoir 2 miles southwest of Clinton. At the "Dug-way," 2

[1] Geol. Soc. Quar. Jour. Lond. 1868. 24:351–400.
[2] Am. Assoc. Adv. Sci. Proc. 1879, p. 311–410.
[3] U. S. Geol. Sur. Bul. 52, especially p. 44–56.
[4] Jour. Geol. 1908, v. 16, especially p. 285–94.

miles south of Clinton, a 2 inch layer of green shale is locally present a few feet above the basal green bed. Scattered throughout the red shale are numerous green spots and after a shower the colors are intensified so that the light green spots stand out in sharp contrast against the dull red matrix. The formation is everywhere highly jointed and soon after exposure to the weather the rock crumbles to a fine dust. The shale is very fine grained and, except for color, it is remarkably uniform from top to bottom. So far as observed it is entirely devoid of stratification planes. Thus it is evident that deposition of the sediment must have occurred in quiet water and under very uniform conditions. Except for certain organic patches below referred to, not a trace of a fossil has been found in the formation near Clinton. At Syracuse the salt bed rests upon the Vernon shale and the absence of fossils from the shale is probably due to the fact that just before the real salt pan conditions the water was too saline to permit much, if any, animal life.

Origin of color in the red shale. The red shale is very fine grained, but examination of the powder or the thin section shows it to be made up chiefly of tiny quartz grains which are imbedded in a red matrix of earthy or claylike material. Occasionally small rhombohedral crystals of some carbonate are noticeable. Because of the opacity and softness of the shale thin sections are difficult to make but it is evident that the color is not inherent in the quartz grains which are themselves very clear and free from color. This is in harmony with Russell's[1] observations on the Newark sandstones, that "their color was not inherent in the particles composing them, but was due to a fine, amorphous, claylike coating which enveloped the grains and filled the intervening spaces."

The red color is unquestionably due to the presence of dehydrated ferric oxid. On treating the red shale with hot hydrochloric acid the red color quickly disappears because the ferric oxid dissolves and from the solution a good precipitate of brown ferric hydrate is obtained by the addition of ammonia. Quantitative tests by Dr A. P. Saunders of Hamilton College showed that a sample of the red shale, treated with hot dilute sulfuric acid, contained 2.25% of ferric iron and .75% of ferrous iron.[2] The amount of ferric

[1] *op. cit.* p. 44.

[2] The amount of ferric iron here given is doubtless greater than is actually present in the oxid form because the acid was boiled until it became concentrated enough to effect a partial decomposition of the green silicate residue below referred to.

oxid is thus very small, but, because of its fine state of division and its diffusion through the mass, it has become very effective as a coloring agent. Barrell[1] discusses this point and believes that where even a very small percentage of the ferric oxid is thoroughly diffused through a rock mass it has great coloring power. It should be stated that after treatment with the hot acid a green insoluble residue is left, whose color disappears after prolonged boiling with concentrated sulfuric acid. Under the microscope this green residue, whose color is doubtless due to the presence of glauconitic material, looks like the ordinary red shale except for color. The final residue is made up chiefly of clear, tiny quartz grains. The relation of the ferric oxid to the glauconite could not certainly be made out but they appear to be very intimately mixed in the earthy matrix surrounding the quartz grains. The origin and significance of the glauconite will be taken up later.

We may now inquire whether or not the red color was present when the shale was deposited. According to Russell's[2] hypothesis, namely "that the sands forming the sandstones of the Newark system and other similar formations received their incrustation of ferric oxid (red) during the subaerial decay of the rock from which they were derived," the red color was present at the time of deposition. Barrell[3] comes to quite the opposite conclusion, especially with reference to red beds associated with salt and gypsum as e. g. in Nova Scotia, the Permian red beds east of the Rockies, etc. Like these red beds, the Vernon shale is also associated with salt and gypsum and was also deposited in rather highly saline water under an arid climate. As Barrell[4] says the lack of the red color at the time of deposition is well borne out by the "usual present development of salt and gypsum in association with gray or yellow sediments." He cites such examples as the Dead sea and the salty flats of the Great Basin of the United States. It is evident that red or reddish brown colors greatly predominate in ancient iron-bearing formations, while the yellow tones, outside of the tropics, are much more characteristic of the modern alluvium.

It is well known, especially as a result of the Challenger[5] dredg-

[1] *op. cit.* p. 289.
[2] *op. cit.* p. 56.
[3] *op. cit.* p. 290.
[4] *op. cit.* p. 290–91.
[5] Challenger Report on Deep Sea Deposits, p. 337 et seq.

ing, that red clay is now forming as a widespread deep sea deposit particularly in the Pacific, but these clays are practically confined to the neighborhood of volcanic regions and they are considered to be due chiefly to the deposition of volcanic dust. Obviously this mode of origin will not apply to the Vernon red shale because it is a terrigenous rather than a deep sea deposit. Some red mud[1] is now depositing locally as in the Yellow sea and along the coast of Brazil, but it is being derived from moist, tropical regions where conditions are favorable for spontaneous dehydration of the ferric oxid. Such dehydration of ferric oxid under conditions of warmth and moisture is well known to account for the deep red color of laterite, the soil so characteristic of the tropics, and which colors the river silts. The climatic evidence is opposed to such an origin of color in the Vernon red shale.

Applying Barrell's view, the iron in the Vernon shale was present at the time of deposition in the peroxid form, but hydrated and therefore not red, and the dehydration with resulting red color was largely due to great pressure and moderate temperature in the consolidated and deeply buried sediment, since hydrated ferric oxid readily gives up its water under such conditions. This dehydration, combined with the finely divided and diffused ferric oxid, the writer believes accounts for the red color of the Vernon shale.

Very commonly stains of yellowish to yellowish brown oxid of iron may be seen along fractures in both the red and green shales, and these are clearly due to the hydration of some of the ferric oxid since exposure to the weather.

Origin of the green spots. As already stated one of the striking features of the Vernon formation is the presence of numerous light green spots scattered through the dull red shales. So far as tested the material of these green spots is precisely the same as that in the green shale beds in the formation. The spots range in size from a fraction of an inch to several inches in diameter. They are mostly spheriodal to flattened spheriodal and seldom irregular. When flattened the long axes lie horizontal thus suggesting that the flattening has been due to the pressure of overlying strata and this since the spots were formed. The green spots are nearly always in sharp contact with the surrounding red shale but,

[1] "Mud is a mixture of minerals in a state of extremely fine mechanical subdivision, but not chemically decomposed, thus differing from clay." Scott's Geology, 1907 edition, p. 267. The Vernon shale is essentially a hardened mud.

aside from color, there appears to be no difference in character between the red and green materials. Although the spots are very irregularly arranged they are, nevertheless, pretty uniformly distributed through the whole mass of red shale, and it is estimated that they make up less than 2% of the mass. Another fact of importance is the frequent presence of dark to black centers in the green spots. Such dark centers which are particularly well shown in Kirkland glen, range in diameter up to a half inch and they are rarely concentric. A much lighter shade commonly extends from the black center well out toward the periphery of the green spots. These dark centers are certainly organic, the dark color being completely removed by heating before the blowpipe.

After treating the green spot material with hot hydrochloric acid a green glauconitic residue is left precisely like that from the red shale. Ferrous iron has gone into solution as shown by the heavy blue precipitate with potassium ferricyanide. Ammonia, however, fails to give the brown precipitate for ferric iron, while sulphocyanate gives only a slight coloration. This coloration is doubtless due to the fact that by infiltration a small amount of hydrated ferric oxid has comparatively recently been mixed with the green spots. Ferric oxid is, therefore, practically absent from the green spots. According to an analysis made by Dr A. P. Saunders, a sample of the green spot material contained 1.19% of ferrous iron obtained from the dilute sulfuric acid solution. The writer believes that the ferrous iron is largely present in the carbonate form. Both the red and green shale when treated with cold hydrochloric acid show almost no sign of chemical action but after warming a vigorous effervescence sets up and this suggests iron carbonate. This carbonate doubtless forms the rhombohedral crystals seen in thin section.

Many years ago Vanuxem[1] described these green spots and stated that: "It is not easy to resist the impression that the green color is the result of a change in the red particles, the peroxid of iron being reduced to a protoxid." He makes no mention of the black organic centers. His view is still commonly held but there are certain objections to it as for example the highly improbable assumption that the red color was original and the fact that the chief coloring matter in the green shale is glauconitic and not protoxid of iron.

[1] Geol. 3d Dist. N. Y. 1842. p. 97.

Maw,[1] in referring to green spots in general, stated that: "The generally accepted theory, and that suggested by De la Beche in explanation of the phenomenon, is, that the discoloration has been brought about by the reduction of the sesquioxid to a lower state of oxidation of less coloring power by simple chemical reaction with the fossil carbon." The objections above given apply in this case also but the influence of the organic matter is here clearly brought out. As early as 1831 Fleming[2] recognized the agency of decomposing organic matter in the production of the light colored (but not green) spots in the Old Red Sandstone.

It is well established that decomposing organic matter will effect the reduction of ferric to ferrous iron and the organic matter in the green spots of the Vernon shale has no doubt caused such a change, but since, in this case, the ferric oxid was in the hydrated state and hence not red, it is not correct to say that there was a change in color from red to green. Rather the writer believes that the presence of the organic matter has simply prevented the appearance of the red color in the immediate vicinity because the oxid of iron has here all been reduced to the ferrous condition. Within the spots, then, the green color of the glauconite is allowed to come out, and it is this rather than the small percentage of iron in the ferrous condition which gives the green color. In each case the size of the green spot has been directly dependent upon the amount of the decomposing organic matter. The presence of ferrous iron in both the red and green shales may be readily explained because this iron is probably mostly in the carbonate form which would be pretty freely disseminated through the whole shale mass.

Origin of color in the green shale. In view of the above statements the explanation of the origin of the color in the green shales, at the base and the summit of the red shale, becomes a comparatively simple matter. The character of the material in the green shale is, in every way, like that in the green spots and the explanation of the origin of the color in the spots may be applied here also. In this case, however, the organic matter was probably more abundant or, at least, it was more finely divided and scattered through the mass so that all of the ferric

[1] *op. cit.* p. 371.

[2] "Old Red Sandstone" by Hugh Miller, quoted on p. 235.

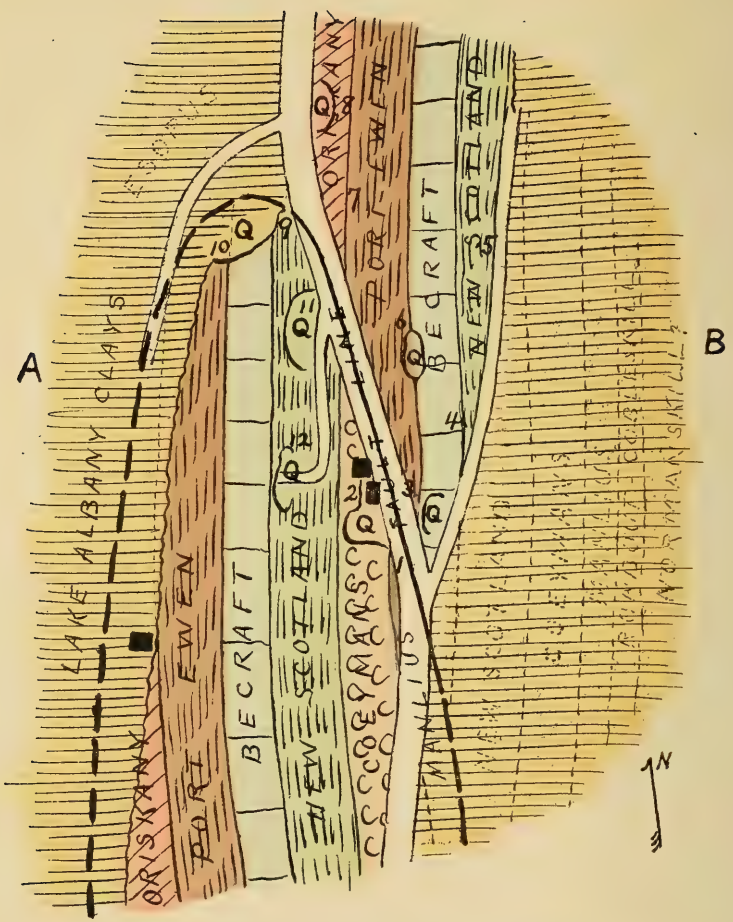
oxid in the green beds has been reduced and there the green glauconitic color appears throughout. In the same way the color of the green streak in the red shale, above noted, has been produced.

Regarding the origin of the glauconite in the Vernon shale the writer ventures to suggest that the conditions for its formation were very favorable such as the deposition of the fine ferruginous sediments very slowly and uniformly at the so called "mud line," in the presence of decomposing organic matter. Since the waters were rather highly saline and since no trace of fossil shells has been found, it is conjectured that the organisms were plants of the seaweed type. It is well known, especially by the studies of the Challenger[1] expedition, that greenish glauconite muds are now forming in the presence of decomposing organic matter over considerable portions of the ocean bottom particularly near the borders of the continental shelves. In the case of the Vernon shale there was an excess of ferric oxid over that necessary to the formation of the glauconite and the dehydration of this excess oxid, as above explained, has given rise to the red color of the shale.

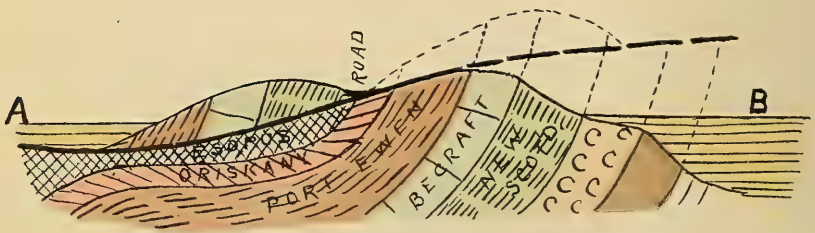
In Kirkland glen an interesting example of the effect of modern decomposing organic matter has been observed by the writer. Along a joint plane for 6 or 8 feet the ferric oxid has been reduced so that, for an inch either side of the joint plane, the shale is green. This is thought to be a purely superficial effect since the hillside is heavily covered with humus and surface waters charged with humic acids have traveled along the joint plane thus causing a reduction of the ferric oxid so that the green glauconitic color is brought out.

[1] *op. cit.* p. 385–91.

Plate I



Sketch map at stone crusher, Canoe hill, Saugerties, N. Y.



Section along A-B of above map, showing structure and derivation of the fault block

DOWNWARD OVERTHRUST FAULT AT SAUGERTIES, N. Y.

BY GEORGE H. CHADWICK

Canoe hill, north of Saugerties village, Ulster co., is represented on the Catskill topographic sheet as a dumb-bell ridge with the highway passing obliquely across the narrowed middle. It is surrounded by clay plains of Lake Albany age, along which, on the west and north of the hill, runs the West Shore Railway. The Canoe ridge is a part of the range of Helderberg limestone hills, known locally as the Kalkberg (pronounced collabarrack,—"Collar Back" of the map!), which here sags under the Albany clays, its summits rising as a chain of islands out of the plain.

During a recent visit to this hill in company with the two gentlemen named beyond, the writer was impressed by the occurrence here of an overthrust almost identical with those in the Vlightberg at Rondout [*see* van Ingen & Clark. Disturbed Fossiliferous Rocks in the Vicinity of Rondout, N. Y. N. Y. State Mus. Bul. 69]. Although it seems likely that this fault has been observed by others, no reference to it now occurs to the writer, and a brief account, with diagrams, is therefore presented because of the conspicuous nature of the faulting and the more ready accessibility of the locality as compared with the Rondout faults.

The locality is in the first hill northeast of Saugerties depot, and not over a mile distant. The map [pl. 1] shows the road crossing the hill in the oblique valley determined by the fault. The village stone crusher, located at the corporation line, furnishes a conspicuous landmark for the visitor. Opposite this, on the east, a blind road leads under the hill. Various quarries and diggings [Q] add to the ease of study of the ledges which are everywhere conspicuous.

The rock at 1, by the roadside as one turns into the crusher quarry, is much brecciated and shot through with calcite seams. It looks like upper Manlius, but no fossils were found. The brecciation is probably due to its lying in the fault zone. At 2, the cliff face behind the stone crusher, the limestone is hard, blue and vertical, with calcite veins and geodes. The fossils are Sieberella galeata, Favosites etc., of the Coeymans limestone. Passing across the highway to 3, where the Manlius would

naturally be expected, the rock is found to be a bluish impure calcarenite with Leptaena rhomboidalis, unlike the Coeymans and not so steeply inclined. This grades rapidly downward (easterly) into a coarsely crystalline "coquina" rock, carrying Spirifer cyclopterus, with greenish shale partings in the lower portion (at locality 4)—unquestionably the Becraft limestone. Mr Cole reports Spirifer macropleura abundant in the shaly limestone below this, along the road at 5 and beyond, indicating the New Scotland. The rock at 3 is therefore the lower Port Ewen, with which it fully accords. The basal bed of this, close down upon the Becraft, carries some chert nodules, as at Catskill.

The Becraft and Port Ewen have an almost unbroken outcrop northward along the ridge. A digging at 6 shows plenty of Aspidocrinus in the upper Becraft, and a gradual change of rock texture at the contact with the Port Ewen. The higher layers of the latter begin to appear, and are decidedly shaly and with oblique schistosity, as at Rondout. They occasion a slight depression and are not well exposed. Beyond them again are harder layers, somewhat cherty, at 7, forming a slight ridge; they carry Leptocoelia flabellites abundantly, also Spirifer cyclopterus and are either the highest Port Ewen (beds 22 to 26 at Rondout) or lowest Oriskany. In appearance they resemble the Hudson valley "Schoharie grit." The dip is steep and the surface of the highest layer has been largely uncovered in a road-metal digging at 8. Here only the talus is being removed and the rock face is untouched but bared. It is horizontally glaciated, and a striking feature of the polished surface is the occurrence of Taonurus caudagalli as lighter colored spiral patches resembling paint blotches. Polished chert nodules also appear prominently. Slightly exfoliated surfaces show the normal burrow structure of Taonurus, side by side with Spirifer murchisoni and Leptocoelia. This is therefore undoubted Glenerie Oriskanian and indicates a rapid loss in calcareous content in the few miles between Glenerie and here.

Standing in this pit, one looks against the north end of the other (or fault-block) ridge, with its nearly vertical beds well shown in an old quarry cutting. The nearest rock, at 9, is New Scotland shale with beautiful and frail silicified fossils, such as are found in it at High Falls station on the Kingston &

Ellenville (O. & W.) Railway. These are wholly different in appearance from the silicified shells of the Oriskany, Port Ewen or Kalkberg limestones and are readily distinguished. They come from essentially shaly layers, are very delicate, neither thickened, coarsened nor iron-stained but often semitranslucent blue with the finest edges and markings sharply preserved. The transition to the Becraft and thence to the Port Ewen is completely revealed, with excellent collecting opportunities. At 10, the west side of the same quarry, it appears impossible to draw the Becraft-Port Ewen contact at a bedding-plane. The two rocks are perfectly continuous, only the change of fossils and the appearance of chert nodules marking the inception of the Port Ewen. This is unusual; a distinct bedding-plane separates them at Rondout, Alsen and Catskill.

From 10 a red barn is seen to the south, under the west base of the hill. Mr Cole states that beds with many Homalonotus vanuxemi, supposedly Oriskany or perhaps upper Port Ewen, occur from this barn southward, having a low westerly dip.

Returning along the highway, another big cutting at 11 shows the same fossiliferous New Scotland shales as at 9, and these beds are being excavated again at 12, here quite vertical to beyond vertical at the top. No attempt has been made to discriminate the Kalkberg limestone in the field or on the map, from the underlying Coeymans.

The offset between the two halves of the hill is plainly evident. Only the narrow highway separates outcrops as discordant as Oriskany and New Scotland, or Port Ewen and Coeymans, and this highway is seen to lie in an oblique hollow across the hill having every earmark of a fault valley. Standing on the north of the road, say at 6, the fault plane is felt to be the hill slope on which one stands, dipping at a low angle to the westward and a steeper angle to the southward. The fault block is like the decapitated crest of this hill, slid westward and slightly downward for the space of two or three hundred feet upon the yielding surface of the Esopus shale (which makes the next ridge to the west beyond the railway), just as at Rondout. Of course, as a matter of fact, the slip took place under much overlying rock and the present forms are erosional. The movement was a true overthrust, not a landslide. One is tempted to inquire whether this is not a piece of the identical fault

which appears at Rondout, and whether it is not also one with the similar horizontal overthrust described by Davis at Austin's millroad near Catskill [Folded Helderberg Limestones. Mus. Comp. Zool. Bul. v. 7, No. 10, fig. 3 and p. 324], with like puzzling features (not yet worked out) in the Kalkberg at Alsen and Cementon, and finally with the great fault near Schodack Landing and southward along the Appalachian front into Georgia. The influence of such a plane, nearly horizontal but rising and falling in great gentle undulations, would affect a wide area (compare the Rome folio, in Georgia) and produce seemingly very irregular, disconnected and puzzling results, especially where it hades, as in this case and so often, considerably beyond the horizontal.

If not one and the same plane, these instances must at least appertain to the same set of movements, the same "rift," extending along the entire eastern edge of the folded Appalachians as a constant and normal feature. The recognition of this for our miniature Appalachian hills of the Hudson valley will assist the field worker materially and will rapidly multiply the known occurrences of this structure.

The writer owes the opportunity for these observations to the Rev. Thomas Cole, Episcopal rector at Saugerties and an acute observer of local geology, in company of whom and of Prof. J. W. Eggleston of Harvard the reconnaissance was made.

JOINT CAVES OF VALCOUR ISLAND — THEIR AGE AND THEIR ORIGIN

BY GEORGE H. HUDSON

Wherever the shore of Valcour island consists of the purer dolomite limestones of the middle Chazy beds, it has been penetrated, sometimes to considerable depths, by a number of small caves which owe their origin in great part to the solvent power of water. The majority of these caves seem to have had their beginnings in exposed joint or fissure planes, and as a rule they have closely followed them in their subsequent development. Such deviation as exists is expressive of a well marked tendency to develop vertically. The form is usually somewhat wedge-shaped with the apex of the wedge uppermost, and in the smallest caves this edge may sometimes be seen to be working upward across a dipping bed without any apparent fissure or joint plane as a guide. If the small cave has penetrated to considerable depths the inrushing volume of water from a wave condenses the cave air and this in turn shoots out a smaller volume of water at the cave top with great velocity. These spouting caves lose the sharp upper edge of the wedge and develop arched tops. The roofs of those caves which rise still higher and reach or pass the present high water mark of the lake, lose also their wedge form and develop wide arches or even flat roofed tops. In the latter instances it is apparent that cave-widening agencies have become more effective than those bringing about upward extension. A few caves have been developed upwards far enough to reach the cliff top. Among these are to be found a still smaller number that have had a portion of the roof fall in some distance back from the shore line. These therefore present us with small sink holes and natural bridges. Where these caves occur they develop in rather close proximity to each other, so one has to go but a few rods to pass many small mouths.

The general external appearance of these caves where well developed, may be seen in plate 1 — a view of a portion of the north shore of Paradise bay on the east side of the island. The wedgelike form and close proximity of the caves are both well shown. The cave near the middle of this view has a sink hole some distance back and a natural bridge between it and the sea wall. A view of this small sink hole is shown in plate 2. The sea wall here faces southeast by south and is only subjected to strong wave action during

southerly gales. A breaking wave rarely throws spray as high as the top of the cliff. Where the lake bottom, just off the foot of the cliff, can be seen at low water, it is found to consist mainly of bare bed rock. Pebbles as abrading tools can rarely be used against this wall and the water here never picks up enough sediment to become in the least discolored.

Plate 3 presents a view of a portion of a cliff about a mile distant from that shown in plate 1 and on the opposite or west side of the island. Here the wall faces west by south. A few of the caves developed on easterly running joints have somewhat the appearance of bedding or pebble-eroded caverns. It may easily be seen that the influence of the bedding in their formation was slight, for the lower portion of the cliff does not differ enough from the upper in character to make it a very effective factor. Neither can we very seriously entertain the idea that they were pebble-cut, for the water near their mouths is now too deep to allow waves the use of any visible abrading materials. Waves can break against these cliffs only during westerly winds. The nearness of the mainland prevents a very heavy sea and westerly winds in this region are of short duration. A little to the left of the region here shown the cliff face turns easterly and there, on southerly running joints we find the typical wedge-shaped forms like those shown in plate 1. A little to the left of the center of plate 3 is a cave opening that reaches nearly to the top of the cliff, the cave here developing on a southerly running joint or fissure. This cave has maintained much of its wedgelike character and the influence of neither weaker bedding nor pebble-cutting is at all apparent in the outlines of its mouth. In their earlier stages all of these caves were no doubt developed through the same agencies. A very large part of the present difference between the caves shown in plate 1 and those shown in plate 3 may be due to the effects of glaciation acting on the latter. We may note that southerly facing cliffs would be in a measure protected from strong glacial action while westerly facing cliffs would receive no protection from a planing action which would cut across their cave mouths. The form of the most distant large cavern on plate 3, the shape of the cliff face just south of it, and the stranded boulder removed from this wall, all suggest glaciation as a modifying agent. Additional evidence to this effect will be presented.

Near the cliff shown in plate 1 is a small island called Spoon island which is separated from Valcour island by a narrow glaciated channel. A portion of its west wall as it appeared October 2, 1909,

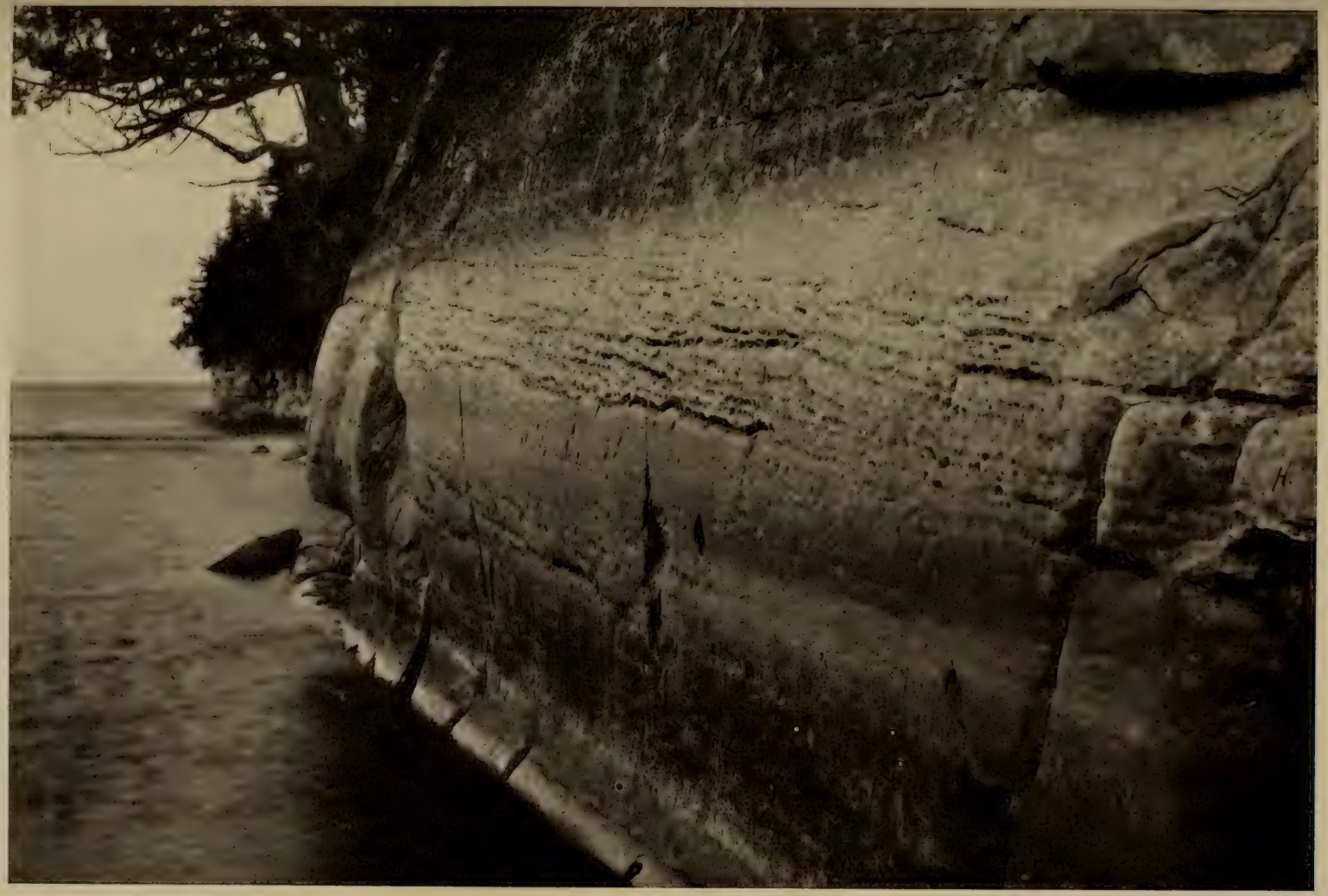
Plate 1

Cliff in Paradise bay (on east side of Valcour island) facing southeast by south. The cave near the middle is open at the top near the face of the cliff and has a sink hole some distance back with a small natural bridge between. From a photograph taken in 1902

Plate 2

View of a small sink hole some distance back from the cliff face shown in plate 1. There are indications here that this opening was due to the crushing in of the cave roof by the pressure of glacial ice. The small light spots in the lower left part of this opening are portions of the distant cave mouth. From a photograph taken November 2, 1909

View of a portion of a cliff on the west side of Valcour island near the lighthouse. From a photograph taken October 9, 1909. The cliff here faces west by south.



A portion of the west wall of Spoon island from a photograph taken October 2, 1909. The cliff here presents an undoubtedly glaciated surface which retains, apparently, the younger and inner ends of caves whose older and outer portions were carried away during the movement of the Wisconsin ice sheet.

is shown in plate 4. This wall still retains for the greater part its former glaciated surface. The whitish horizontal band, due to the dried remains of a sheet of green algae which covered this portion of the wall in the spring, is an indication of the water level at that time. It may be noted that the portion of this wall covered by water the greater part of the year is better preserved than either the portion only covered in spring or the portion above this which is now never covered. The water surface shown in this plate cuts across the mouths of several small wedge-shaped caves or cavelets and their appearance is very suggestive of glaciation after their formation. The clean and sharp junction with the smooth curved glaciated wall makes them appear like the younger ends or remnants of older and larger joint caves. The fact that a very marked and glaciated notch has been cut out from the under portion of the cliff just north of them and at their level, may be taken as indicating that a few closely packed joint caves had here so weakened the cliff as to allow glacial action to carry them in part away. Their former presence is shown by their bases which still exist. The well preserved character of this portion of the wall is due to the proximity of Valcour island on the west, to a bar at the north (here indicated by the faint lines of surf), and to the fact that waves from the south are broken by cliffs as they enter the channel.

There are a few instances in which these caves have followed bedding planes, and cut such wide and deeply penetrating caverns as to bring down great masses of the rock above. Plate 10 represents a portion of the shore of Valcour island as seen from the south end of Spoon island October 23, 1909. The great fall of rock at the left end of the cliff is due to the collapse of such a cavern. A little to the right of the middle of this view there arises from under the water a second low but wide cavern which follows the bedding plane seen at the right. The vertical dimensions of this cavern become rapidly less as we move up along the bedding plane and they become practically zero before we reach the highest part of the dried algae belt, plainly seen as a whitish band parallel with the water surface. The width is considerably greater than here shown because it extends to the left under water. The distance to which it penetrates the cliff horizontally was greater than could be determined. The wall here is a north and south fault scarp, is on the upthrow side and is but a few meters from the fault line itself. Not far back of this we find a few parallel faults with very small vertical displacement, but revealing, by slickensided surfaces, a larger horizontal component. The cliff to the right of the portion

here shown presents some nearly horizontal joints which curve up southerly and cross the beds. The block here has been subjected both to a strong uplift and to a thrust toward the south. The indications of vertical and lateral displacement make it quite possible that these aberrant caverns are also following some preexisting planes of fracture, and that they are in their origin not essentially different from the caves first mentioned. The other cave mouths which show on this plate illustrate clearly the tendency to acquire verticality.

Now numerous as these joint caves are, they are found with a single exception where the present water line of Lake Champlain either just keeps them covered or cuts across their mouths during some portion of each year. The high water level of spring leaves but comparatively few of them uncovered, but the number brought into view rapidly increases with the lowering of the water level. In other words, the floors of all but a very small number of these caves lie a meter or more below the present low water level of the lake while their roofs stand at varying hights above this level, some of them reaching far above that of present spring floods. Their horizontal depth is not so easily measured but many small mouths give forth deep bass notes when any sea is running and their booming may be heard for considerable distances. A few can be followed into the cliff for several meters but a narrower portion may be always seen to penetrate to still greater depths. Plate 5 shows a sink hole many meters from the shore line and the sink hole shown in plate 6 is 150 meters from the nearest lake margin.[1]

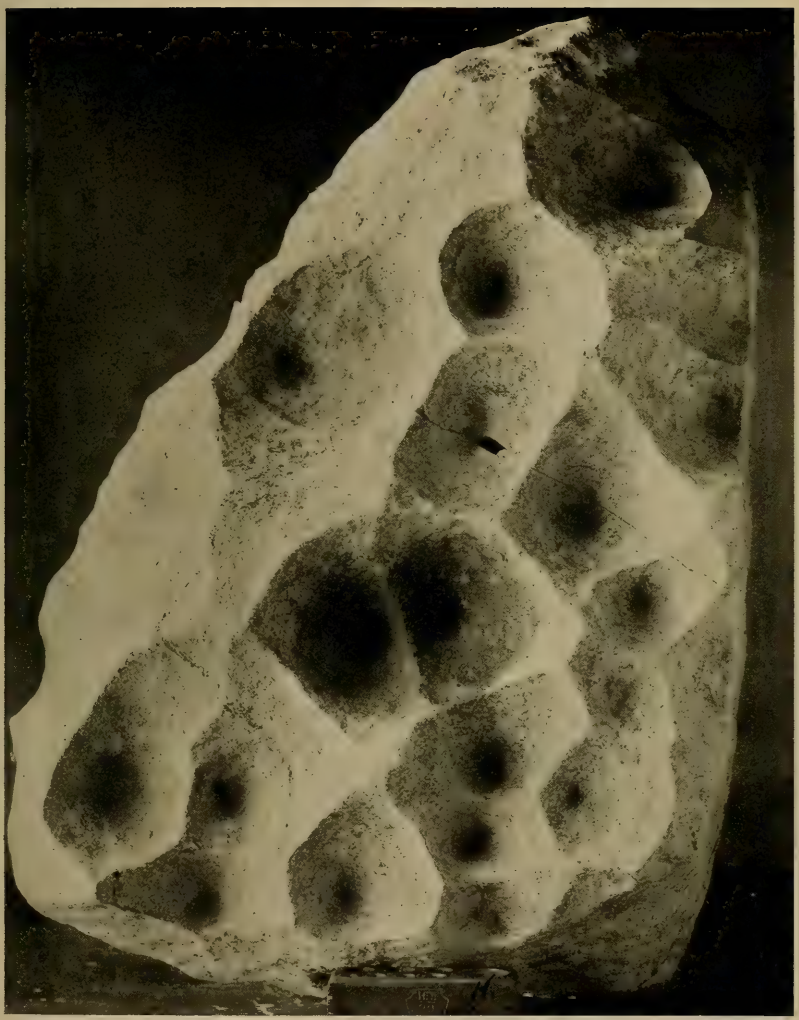
[1] The sink holes shown in plates 5 and 6 both seem to be of comparatively recent origin. In plate 5 a border of fresh earth, on which nothing was growing, is to be seen around the front of this opening. This feature and the overhanging sod at the left are indications of the removal of much earth in a single season. If anything like an equal amount has been washed out each season the sink hole can not be many years old. That it was covered in comparatively recent times is also shown by the presence of portions of old stumps and roots on the rock surface of the more distant border of the pit. It does not seem likely that we are here dealing with a recently fallen rock roof but it does seem likely that such a roof was crushed in during the last stages of the ice sheet and that the opening was then filled with till and afterward covered by Pleistocene deposits. As soon as the present land had lowered sufficiently to allow waves to run in and out of the cluster of narrow caves here seen to connect this pit with the lake, the water would undermine and carry away these deposits and so allow the surface to finally cave in. Such a conclusion would make the caves connecting this pit with the lake, preglacial.

View of a sink hole on the west side of Valcour island, a short distance south of the old steamboat dock. The person in the hole is holding up a meter stick vertically, the arrows marking the ends of the stick. From a photograph taken October 16, 1909

Plate 6

Sink hole on the lower terrace (meadow) of the north farm and 150 meters from the west shore of Valcour island. From a photograph looking north by west and taken October 10, 1909

Plate 7



Block of pure dolomitic limestone, of Lowville? age, cut by confluent cupholes. Vertical distance from table surface to upper point of block 463 millimeters. Specimen now in the New York State Museum

Plate 8

View of fractured end of the lower portion of the block shown in plate 7. Presents a side view of the cupholes and forms of figures produced by nearly vertical sections of the same. Shows also the edge of the dent-pitted surface below, and indicates approximately the comparative value of the two forms of erosion as geological agents

The very marked relation of these caves to the present water levels of Lake Champlain strongly suggests this lake as their cause. On the other hand, the vertical depth to which they descend below low water, their increasing number at the lower levels, their great width and horizontal depth, their appearance on fresh glaciated surfaces and their apparent modification by glacial action, all strongly suggest a preglacial origin for them and leave them as rock inscriptions commemorative of lake Valcour.[1]

During the past season these caves have been studied with the hope of finding evidence which shall serve in determining their age and the manner of their origin. It is the purpose of this paper to present the evidence found. The first of this evidence deals with a peculiar feature of erosion found on all cave surfaces which have been acted upon by the present lake waters. It will be necessary to treat this feature somewhat in detail and this we propose to do under the subtitle which follows.

Dentpits. The beds of the uppermost Chazy are in part covered where they crop out at the northeast corner of the island, but under the water of the lake and some distance out from the shore line, wave action has swept them comparatively clean. During the period of phenomenally low water in 1908 a series of samples of these beds, which run from just below the sandstone capping of the Chazy to the beds of the Black River epoch, were secured. One bed of very pure dolomitic limestone of Lowville age (?) was deeply cut on its upper surface by confluent cupholes[2] whose edges were so sharp that it was an exceedingly painful matter to stand on them barefooted even though the water was more than a meter deep. This bed had been undercut, and a large block had fallen from its edge and now lay in a number of smaller pieces. These pieces however still remained in their proper relations to the bed and to each other and none of them had been turned over by wave action. On raising a piece of this bed weighing a little over 46

The sink hole shown in plate 6 is in a meadow on the lower terrace of the north farm and seems to be a still more recent opening. This hole had been partially filled up with some old cedar stumps, and three upright poles served to indicate its position to any one mowing the field. These stumps and one of the poles were temporarily removed in order to obtain a view of the rock edges in the opening. This opening was not sufficiently illuminated to allow its interior to show any detail in the photograph.

[1] *See* Some Items Concerning a New and an Old Coast Line of Lake Champlain. N. Y. State Mus. Bul. 133, p. 159–63.

[2] *loc. cit.* p. 160–61, pl. 1–5 inc.

pounds, my attention was called to the very peculiar and clearly cut pattern on its under surface. As this block must be considered in evidence, it is represented here on plate 7 to show its upper surface, plate 8 to show a section through upper and under surfaces, and plate 9 to show the under surface.

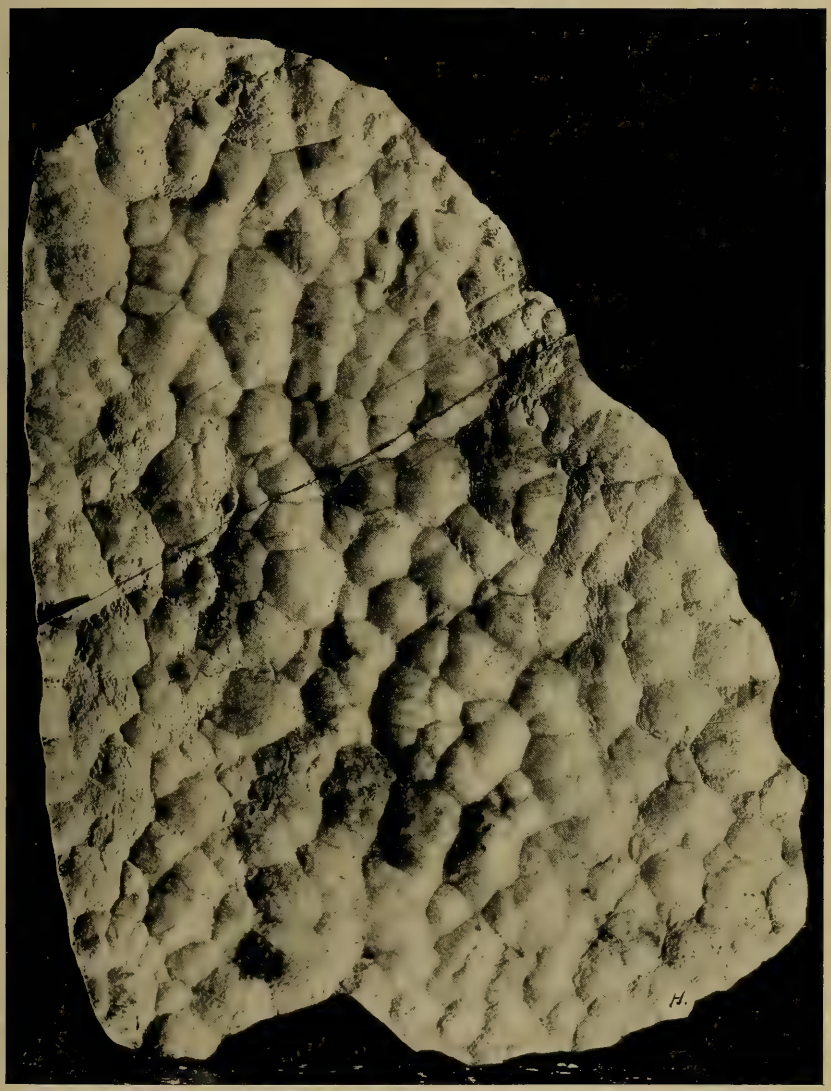
During the early summer of 1909 an examination was made of the cave whose arched mouth, rising just above the whitish dried algae band, may be seen a little to the left of the center of plate 10. Here a peculiar erosion pattern similar to that on the under side of the limestone block referred to [pl. 9] was discovered but with this difference: on the limestone block the surface was of small area and all the dentlike depressions were confluent; here the pattern was spread over many square meters of surface and varied in its degree of complexity all the way from the separate circular depressions near the mouth of the cave to the horizontally alined and crowded pattern of the deeper recesses.

Plate 11 is from a photograph of a portion of the north wall of this cave taken August 1909. The depressions are least crowded in the upper right-hand portion of the plate or in that portion of the cave nearest the mouth and under water action for the lesser portion of each year. A distinct horizontal arrangement of these depressions is to be noted, and we are compelled to attribute it to the direction of the flow of water in and out of the cave during wave action, and not to bedding planes. For convenience in reference we shall call this cave *Bat cave*.

On visiting the recesses of the cavern with a fallen roof, near the left end of the cliff shown in plate 10, a still more remarkable arrangement of these depressions was discovered. Plate 12 is from a photograph taken October 2, 1909. We are here looking westerly across a higher portion of the inclined cave floor, and the lines taken by the confluent depressions are clearly seen to take the natural lines of water discharge. Even in the vertical fissure shown here the lines are not horizontal and neither would be the direction of the outpouring water as a wave receded.

Plate 13 is a view which penetrates deeper into the cavern than did plate 12. The vertical fissure at the left of plate 12 is seen at the extreme right of plate 13. In this last plate the relation of these lines of confluent depressions to the direction of water flow is still more striking. An examination of these two plates will also reveal the fact that the sharpest lines of intersections lie deepest within the cave recesses where they are protected from other

Plate 9



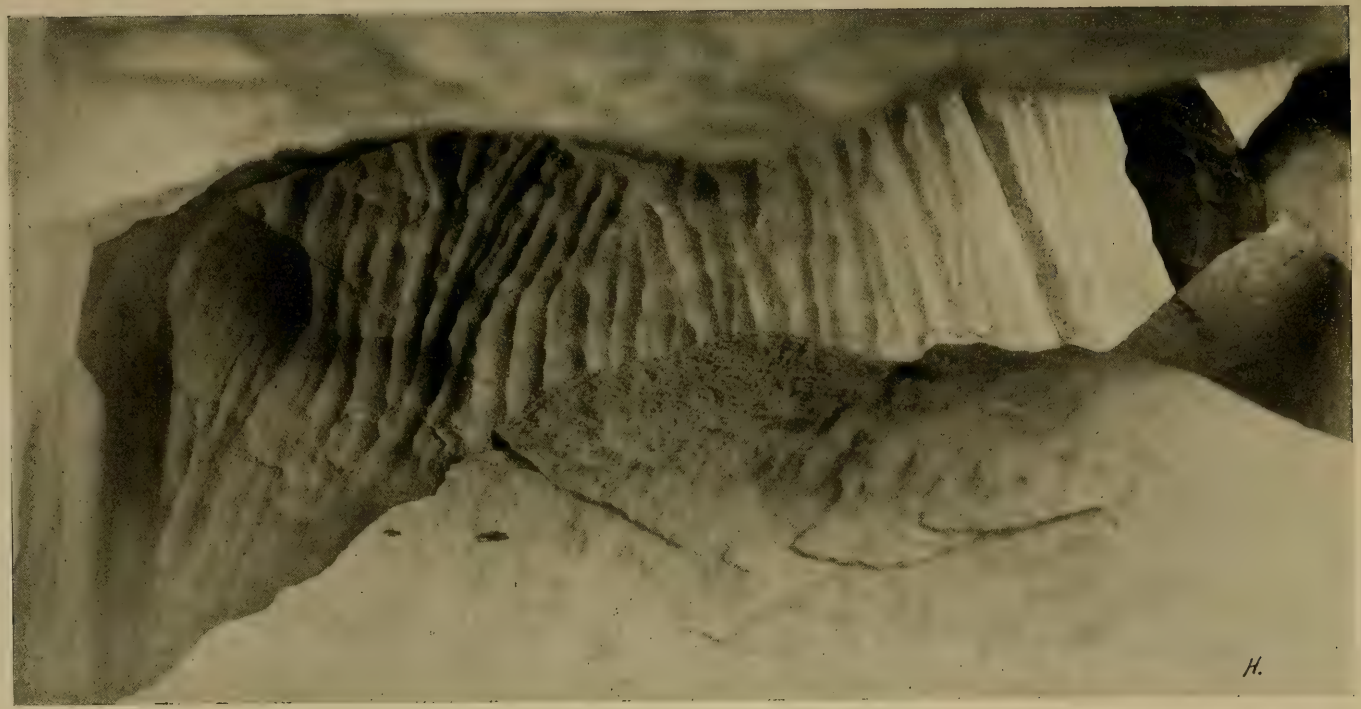
The undersurface of the block shown in plates 7 and 8. Note difference in character of marginal and central dent pits. The former seem to show the results of differential solution due to acids generated by microorganisms. Figure must not have botryoidal appearance.

Plate 10

The south end of the west wall of the channel between Spoon and Valcour islands. From a photograph taken October 23, 1909

View of a portion of the nearly vertical north wall of Bat cave. The surface is covered with confluent dent pits. Their intersections are sharp and these raised edges show no wear from movement of material on the cave floor. The photograph was taken August 1909 and just after the removal of blocks from under the horizontal line *a-a*. The downward slant of these lines toward the right is due to the high position of the camera.

Wave-worn recesses of the bedding plane cavern with the fallen roof. From a photograph taken October 2, 1909. Note the runnels on the inclined floor. They are formed of confluent dent pits and converge toward the place of discharge at the left. Note also the alinement of the dent pits on the left vertical wall of the open joint in foreground.



Wave-worn recesses of the cavern shown in part in plate 12. From a photograph taken October 23, 1909. The vertical open joint at the extreme right is the same as was seen in the middle distance of plate 12. This view, taken through a narrow opening between the rock masses in the foreground (out of focus), looks along and up the lines of flow — not across them as in plate 12. Foreshortening has exaggerated the apparent dip of this surface. See foreground of plate 12 for a truer presentation of the amount of inclination. That these channels are formed of clean-cut confluent dent pits is clearly seen. Note them also on other wall of vertical open joint.

erosive agencies. This feature of erosion is both peculiar and important enough to receive a distinct name, and the name *dentpit* is hereby proposed.

Dentpits defined. Dentpits are vortex-formed, shallow rock concavities whose width greatly exceeds their depth and whose axes are perpendicular to the rock surface. Their diameters are usually between 1 and 5 centimeters, and a separate dentpit has much the same form and smooth character as the concave surface of a watch crystal. Sections along their axes give curves that are approximately arcs of circles whose radii are usually between 3 and 4 centimeters in length. These dentpits when confluent often present an appearance much like that of hammered brass, but their intersections are usually very sharp and clearly defined. Like cupholes they are sometimes seen to be arranged in definite lines which take the direction of the water flow.

The differences between dentpits and cupholes are both numerous and well marked. Cupholes present hyperbolic or parabolic outlines on longitudinal sections. The former are usually between 5 and 15 centimeters in diameter and their depth is usually greater than their width; their axes are always vertical even though cut on the sides of steeply sloping surfaces, and they are cut or deepened directly downward; they usually contain some fine silt in their deepest portions. Dentpits, on the contrary, present circular outlines on perpendicular sections. They are usually between 1 and 5 centimeters in diameter and their depth is very markedly less than their width; their axes are confined to no one direction and their cups may be deepened even directly upward; no silt ever remains in their depressions. Dentpits are developed on rather pure calcareous rocks where the water is strongly agitated by frequently broken and reflected wave motion and where the water carries but little matter in mechanical suspension.

Formation of dentpits. When quiet pure water rests against limestone, molecules and ions of the latter become detached and pass into the water; this process we call solution. The presence of such molecules and ions in the film of water next the rock interferes with further detachments, an equilibrium is soon attained and solution ceases; the water is said to be saturated. If the water has a rapid molar motion it will produce a more rapid solution of the limestone because it never allows the film next the limestone to become saturated, or continually removes it after saturation. The more rapid the movement of the water the more rapid the solution,

provided that the water forced in to take the place of that whirled away is itself unsaturated, and also provided that there is no limit to the speed with which such molecules may become detached when in actual contact with unsaturated films.

In true differential solution we are confronted by a surface whose relief speaks of different degrees of solubility due to differences in chemical or other character of the surface in question. Our recent discussion however should make it clearly manifest that we may have a relief that speaks clearly of differences in motion (speed and direction) of the solvent and dentpits present us with a relief perhaps in great measure so formed.

That a solid rock relief may express this difference in speed and direction and motion of a solvent is also shown by numerous limestone sheepbacks of this region, which exhibit deeply cut rill channels on their exposed surfaces. A typical boss of this character is shown in plate 14. The channels may be seen to start from near the top of a well rounded boss, where they have no appreciable depth, take the natural direction of water flowing down the inclines and sink to a depth of 15 centimeters below the surface before the rill becomes 150 centimeters long. This is a rate of increase of 1 in depth for every 10 linear. These channels are usually subparallel and are often but 20 to 30 centimeters from each other. The only abrading materials which are here to be obtained are atmospheric dust and such particles as are separated from the rock through solution. These rill channels are not wholly due to rainfall but were in some measure due to melting glacial ice. Whatever the source of the water there was a very evident increase in cutting power due to change in velocity as the water passed down the inclines. Whatever allowance may be made for mechanical abrasion, there will still be left a large part of the difference in depth which is due to solution. We may hold this to be another example of differential solution — due not to difference in character of the rock mass but to difference in rate of motion of the solvent.

Where the axes of dentpits are parallel to the bedding planes their surfaces are often crossed by thin laminae containing a large percentage of silica. If solution were the only process used in their formation such laminae should form sharp projecting ridges, yet differences in bedding are so little expressed through relief as to be either not at all noticeable, or to be barely felt by the finger tips. Mechanical abrasion thus seems to have been present at all times.

The sharp edges of the intersections of confluent dentpits at once

Surface of a roche moutonnée about 200 meters north of the north end of Beekman street, Plattsburg, N. Y. Shows rill channels whose rapid deepening is due to greater speed in motion of solvent. From a photograph taken November 1909

demonstrate the fact that no abrasive particle used could have had sufficient mass to enable it to escape from the vortex and cut across this border. On the other hand it has already been pointed out that the water during great storms is never noticeably discolored where these dentpits occur, and that the lake bottom has been swept clean of all fine material for considerable distances from the cliff. The water is not bringing in silt to use in its attacks upon the cliff, but it is in fact removing, through the agency of lake currents, all those particles which are fine enough to remain any considerable time in suspension, and leaving them where the present lake does not have the power to pick them up again. Thus we must conclude that abrasive material of sufficient fineness to do work of this character is apparently conspicuous only by its absence. Some fine abrasive material must however always be present and to such inorganic particles as may be brought, detached, or allowed temporarily to remain, we must add such organic particles of the plankton as the calcareous carapaces of microscopic crustacea and the silicious frustules of diatoms.

There is a border land between solution and abrasion that is but little understood. The points of contact between any two masses may be considered as molecular rather than molar and differential motion between the two masses might detach single molecules as well as clusters of molecules. Increasing speed of molar motion introduces new conditions and unexpected results. A tallow candle is driven through an oak plank; water is made to cut rock in hydraulic mining; our great breech-loading guns, used in warfare, are short lived because escaping gases driven with great velocity cut away the metal around their breach mechanism. The energy of an ounce of hydrogen moving with the velocity of a thousand feet a second is precisely the same as that of a steel ball of same weight and velocity. A stream of molecules driven against a solid may detach not only molecules but masses as well. We may get some idea of this from tornado destruction. Note also the action of air on swiftly moving meteoric bodies. We may then be justified in concluding that there is such a thing as molecular abrasion, that it is a fact to be dealt with in nature, and that it has played a part in the formation of dentpits.[1]

[1] For erosive power of escaping gases on guns *see* Ordinance and Gunnery, by Col. O. M. Lissak, page 260.

For statement that "The erosive effect of the gases appears to depend more on their velocity than on the maximum pressure" *see ibid.* page 550.

One additional point should be made here. The condition of the molecular film of water next any soluble substance must at least be as complex as its molecular film in contact with the air. In the film next the rock surface for instance, there are molecules of water passing into the rock and molecules of rock passing into the water. This film may have exceedingly tenaceous properties, and the greater the difficulty of removing it, of freeing the separate ions or molecules in it through diffusion, the slower will be the process of solution. When the solvent is thrown into rapid motion against this film it not only helps to tear it away but some of its energy is transformed into heat and electricity and before dissipation can take place such transformation may very materially accelerate the process of solution itself. In other words these forces may supersaturate the film while they are in action and relief will be found in forced diffusion aided by mass motion. We may therefore hold for the present that dentpits are the result, in part, of differential solution, due to differences in motion of the solvent; and in part also to molecular abrasion and abrasion by molar particles of exceedingly small mass.

Comparison of potholes, cupholes and dentpits. In pothole formation we have large and comparatively constant vortexes which are capable of moving large pebbles and of giving them a rotary motion of considerable radius. These factors determine size. Gravity plays a very important part in their formation for it determines the direction of the cutting, holds the heavy tools against the bottom with considerable force, and does not allow the vortex motion to lift them and use them against the upper and older portions of the excavation. The side cutting is continued by finer material but the bottom cutting is so greatly in excess of it that deep rather cylindrical holes with well rounded bottoms result. Sections along their axes will give somewhat U-shaped figures.[1]

In cuphole formation the vortexes are markedly intermittent in action, if not reversed, are much smaller, more closely packed together and incapable of handling heavy material. These factors again determine size and also number per unit of area. The part played by gravity is not so important although it still loads the vortex points, determines the direction of their cutting and keeps their axes vertical.

[1] Giant kettles do not differ much from potholes in the manner of their formation though they do in the agent employed and in their size and distribution.

Gravity also still aids in holding the cutting material against the surfaces, retains it there when motion ceases, and adds new material thereto from the water and the air above. On account of the fineness of this material the vortex holds most of it in suspension as an air vortex does dust, and while it cuts down at its apex, gravity is powerless to keep the greater part of the load there and a very marked widening of the older portion of the cut is allowed to take place.[1] Sections along their axes therefore give us somewhat V-shaped outlines but the sides are never straight lines and the figure is more nearly that of a parabola or hyperbola.

In dentpit formation we are dealing with still smaller vortexes and usually with a greater number per unit area. If the vortex is acting against steeply inclined or overhung surfaces at some distance from the bottom, or source of load, it will be able to use only such abrading material as is already in mechanical suspension in the water or which may be supplied to the vortex through the action of vertical currents or through detachment from the rock surface. The deeper the water the finer will the particles be that the vortex is allowed to use. Instead of pressing the abrading material against the surface, as in pothole and cuphole formation, gravity is always working to keep such material away from overhung surfaces and is constantly trying to withdraw from the grasp of the vortex all particles whose specific gravity is greater than that of the water. The material used must therefore be somewhat uniformly distributed throughout the vortex rather than loaded in or confined to a smaller portion, that would thus be itself drawn down by gravity, and the cutting in consequence will be less localized and confined to no one direction. In other words, one portion of a vortex can not cut more than another because of greater load, unless the vortex segregates its abrasive material through centrifugal action, and if so segregated, the result would be a cut showing that widening is carried on greatly in excess of deepening, and this is the form of cut that we actually find. The fact that the effect of gravity on the sediment is here made a negative rather than a positive quantity is in itself a distinction which places dentpits in a distinct class and we must see that they really differ more markedly from cupholes than do the latter from potholes. We may also note that when this cutting is on overhung or nearly vertical surfaces gravity does not allow abrasive material to remain on

[1] It is in this manner that cupholes, such as those shown in State Museum Bulletin 133, plate 4, are cut in the sides of steeply sloping surfaces.

the surface when motion ceases, and brings no new material to this surface during intervals of rest. From the aspect of the question in regard to the influence of gravity we might be led to assert that while potholes and cupholes can be cut only downward, dentpits can be cut in any direction but downward; and under all ordinary conditions the statement would be true. We have seen however in plates 12 and 13 that where waters are comparatively pure, typical dentpits may cut very nearly downward. Where waters hold no particles heavy enough to allow the influence of gravity to become positive and thus interfere with the tendency of the vortex to whirl them freely about, there is no apparent reason why dentpits might not be cut directly downward.

That the recognition of dentpits may become a matter of no little importance, will be seen if we consider them for a moment in their relation as geological timepieces. Niagara has long since become a classic in this respect, and while we realize that the time problem is not so simple as it was first thought to be its value is greater today than ever before and its accuracy as a timepiece will be more clearly understood in the near future than it now is. Giant kettles must be cut with a speed which is in some respects comparable to that with which cauldronlike cavities are excavated at the foot of falls where vortex motion is both great and rapid. The cutting of potholes is a much slower process. When we come to cupholes we are dealing with phenomena which require a very much longer period in which to produce any marked result. The intermittent character of the vortex, its small size, the fineness of the material used, the slight pressure allowed the abrading material at the cutting point, these and other things make the above conclusion an inevitable one. These cupholes show conclusively that at no time since the recession of postglacial Lake Vermont has the water surface remained at any one level so long as it has remained at the level on which these cupholes are cut. Now in dentpit formation we must remember that we are dealing with smaller vortexes and with abrading material so fine that gravity can give it no pressure whatever on the surface undergoing the cutting. This abrasive material is not only exceedingly fine but there is in amount not $\frac{1}{100}$ of that which is allowed or used in the cutting of cupholes.

Keeping in mind the statements just made, let us examine the shores of Valcour island. Where cupholes have not become confluent they are cut on distinctly glaciated surfaces and their

depth rarely exceeds 10 centimeters. Where dentpits have not become confluent they may also be found on glaciated surfaces and the markedly slower process of their formation has rarely allowed them to penetrate to a depth greater than 1 centimeter. Scattered dentpits on an undoubtedly glacial surface may be seen in plate 4, on the smoother surface of the rock and about half way between low and high water. Foreshortening makes them appear as ellipses. A little above this belt and near the extreme right a few more nearly circular outlines may be detected. These dentpits are of precisely the age of the cupholes and both were started on glacial surfaces when the water was lowered to near the present level. Now, just inside of the mouth of Bat cave in the opposite wall of the channel and at the same level, we may also find a few separate dentpits but much better developed than those on the wall outside. Where cupholes have become confluent they have of course destroyed the glaciated surface. In these regions of greater activity the surface may have been cut away to an average depth of perhaps 20 centimeters. Likewise with dentpits, where confluent, the vortexes producing them were the more numerous and stronger and the amount of surface removed may have been as great as 2 centimeters. This is the condition of the cave wall shown in plate 11. Now as this cave is more than a meter wide it follows that *in all its essential features it is as old as the glaciated surfaces on which the dentpits are cut outside.* The recognition of these dentpits and a knowledge of their rate of formation thus enables us to decide a very important question and the answer is evidence of the strongest character for preglacial or interglacial Lake Valcour.

As dentpits stand in such an intimate relation to solution it will be important to consider next this factor in the formation of the Valcour island caves.

Solvent power of Lake Champlain on its limestones. Cystid point, on the southeast shore of Valcour island, seems to be caused by the presence of a fissure, and the little cove just south of it is filled with movable rock debris to a depth of about 2 meters. On either side of this cove the shores consist of bare rock. Suspecting the eastward extension of a fault here, I have made an examination of the visible lake bottom from a rowboat on a perfectly still day at a time of low water in the fall of the year. The condition under water was much like that noted on the exposed shore. A depressed belt over the fissure was covered with boulders and pebbles of various kinds and sizes while, on either side of this, large areas of

bed rock were free from loose material. At some distance from the shore the material covering the belt was such as we should expect to find in a region of washed till. The belt was here neither so wide nor so thickly covered as it was on the exposed shore. Wave action had evidently assorted and built up the shore deposit but the deposit under deeper water seemed to have suffered little if any movement.

Under about a meter and a half of water we noticed a pebble about the size of a cobblestone which was resting with its bedding planes in vertical positions and which appeared to show the results of differential solution in a rather interesting manner. The arrangement of its alternating layers of very fine silicious and calcareous sediments seemed strikingly like that of a peculiar bed found on the island only in the weakest part of the Camarotoechia shales. Its calcareous layers had been dissolved or eroded to considerable depths, leaving the projecting silicious layers as an index of the former size and shape of the pebble. One aspect of this specimen is shown in plate 15.

When broken from its bed, during the last glacial period, or when separated from the larger block of which it may have formed a part, it evidently had the form of a four-sided prism with faces of unequal area. In our figure it is resting on the remaining portions of the largest of these former faces, which is much foreshortened in the view, and it has what is now left of its former smallest face, at the lower front. The latter face has been wholly lost from the softer portions of the stone and these now possess an acute angle in place of it. This prismatic form was considerably modified, during its movement with the till, but was not wholly lost. Glaciation seems also to have added a few facets.

Any marked wave or water action on this specimen must have been absent during the existence of Lake Vermont and the Hochelagan sea, for those were times of deposit in this locality. When Lake Champlain began work at nearly its present level it had first to remove these later deposits and wash out the finer material of the till before it could begin to work on what then must have been a smooth glaciated pebble. The cutting out or the dissolving of the softer portions of this stone must therefore be purely the work of Lake Champlain and of no older body of water. Its study should yield testimony of great value as to the ability of this lake to have formed the series of caves which now lie along its Valcour island shores.

Plate 15

One aspect of a glacial pebble which has lost much of its substance through differential solution and erosion by Lake Champlain

We may first note the exceeding thinness of some of the retained silicious laminae which now project in places as far as three or more centimeters beyond the surfaces of its calcareous layers. The edges of some of these sheetlike extensions are so fragile that they were broken in several places during the careful handling which the specimen received before being photographed. The edge of one recent break may be seen in the middle thin sheet of plate 15 and is shown in plate 16, figure 2. That these and other fragile edges had been preserved shows conclusively not only that the specimen had not been rolled by wave action for ages but also that wave action had not been able to roll or throw smaller pebbles against these edges since they were formed. This witness against the power of wave motion in this locality to use small pebbles as tools of erosion would lead to the conclusion that this specimen, when found, was resting on the same base on which it rested at the time of cessation of motion of the last ice sheet. This may be true, but there are two different times in which this pebble may have been moved and it will be well to note them. The bare areas mentioned may have been first cleaned off by subglacial drainage moving under pressure and the pebble may then have been removed from the till to find permanent lodgment in the more sheltered position over the fissure. If not moved before the ice front passed to the north it could not have been moved until the waters of Lake Champlain had arrived at approximately their present level. While Cystid point is somewhat sheltered from storm action yet it is no easy matter to land here in a rowboat during strong north or south winds. Waves of exceptional force may have swept the till from the bare areas mentioned and moved the pebble to the deeper and better protected position in which it was found. Whether left in this position by the ice sheet or moved thither during either of the periods mentioned above, it could have been subjected to solution or abrasion only since the deposits of the Hochelagan sea were swept away. If for long ages wave motion had been unable to use small pebbles against its thin edges it must have been unable even once to turn this specimen over during that same long period and the erosive features we are about to notice will yield strong evidence in support of this conclusion.

One face of the supposedly dissolved portions of this specimen is unmistakably marked by typical and confluent dentpits with

widths of about 10 millimeters and depths of from 1 to 2 millimeters. The presence of dentpits shows us at once that these softer layers have not been cut away by simple solution but that erosion at the hands of vortex motion has played an important part in the process. Remembering also that dentpits show absence of cutting vortex points loaded with sediment by gravity, we find them in this case indicative of surfaces which can not well have been upper surfaces. The two surfaces on which these dentpits appear are both on the underside of the specimen as it is shown in plate 15, or on the broadest face of the present three-sided interior prism and are only separated from each other by the thin silicious sheet of the middle bedding planes. As in this plate the specimen is resting on the remnants of its older prismatic face of greatest area, which was the position in which its center of mass would be lowest, it would appear that these surfaces were not only undersurfaces when found but that they had been such during the whole age of Lake Champlain. These two dentpitted surfaces of the softer beds of the stone have been cut by abrasion and solution together until they are now 27 millimeters distant from the outer edge of the harder layers or from the probable surface of the stone as the last ice sheet left it. This aspect of the specimen is shown in plate 16, figure 1.

The surfaces of the soft beds which are opposite the surfaces just described are indented with numerous, more conical pits, measuring from 2 to 3 millimeters in diameter and having about half that depth. The cutting here is of the type effected by vortexes whose points are down, and kept filled with sediment by gravity. Though the dimensions of these cuts are so small, they have lowered this surface of the specimen some 55 millimeters. As cutting of this type can take place only in a downward direction the surfaces of the specimen on which they appear must have been upper surfaces. These are the surfaces uppermost in plate 15 and the greater rapidity of the cutting on this portion of the specimen only served to lower its center of mass the more and make its equilibrium still more stable. These surfaces have very probably been upper surfaces ever since the cessation of motion of the last ice sheet. This aspect of the specimen is shown in plate 16, figure 2.

The character of the two soft layers does not change on passing from one side of this stone to the other and the difference

Plate 16

Two views of a water-eroded pebble taken from a little over a meter's depth below lowest water of Lake Champlain. Figure 1 shows the under surface of the soft beds to have been cut by water vortexes in such a manner as to leave small though typical and confluent dent pits.

Figure 2 shows the upper surface to have been cut by many exceedingly small but loaded points of water vortices.

Specimen now in the New York State Museum

in the depth of the cutting is due purely to a difference in the action of the environmental forces. When this specimen was first taken from its resting place no attention was given to its position on the bottom other than that its bedding planes were vertical. In other words it was not noted which side was uppermost. The two distinct types of erosive action we have been discussing have, however, enabled us to very positively determine this matter some years after the date of collection. Not only have they done this but they also have strengthened the conclusion, drawn from the thin edged laminae, that this stone had never been moved by the action of heavy seas but had remained with its dentpitted surface down for several thousand years.

It may here be noted that this pebble yields information of yet another variety. That the floors of many of our caves are a meter or more below the present lowest water level of the lake would in itself be evidence that this lake did not cut them unless it had for a long time been at a lower level than the average of the last hundred years. Now it could not have been that meter lower without having brought the specimen we have been discussing so near to the surface that the waves of storms would have used it as a plaything, deprived it of its thin edges, destroyed the remaining evidences of its former angular outlines and made of it a simple beach pebble. Its fellows would also have been so changed in position as to bear witness of the segregating power of wave action. Our pebble thus yields evidence that goes to prove that the surface of Lake Champlain has never been materially lower than it was in November 1908, and never before perhaps so low.

The old benchmark in Shelbourne harbor made in 1827 marks the exceptionally low water reached that year. Not till 1881 was this mark passed and a new record established. In November 1908 this was again passed by about 2 inches. As the pebble we have discussed is in itself testimony that the lake has never been lower since the period of the Hochelagan sea and as it bears on its surface an index of the work accomplished only since the present lake waters were low enough to uncover this pebble, it becomes in itself a timepiece showing the age of Lake Champlain. In other words this pebble presents clear evidence which goes to show that on the melting of the ice sheet, isostatic balance was quickly restored in this region and a position close to a former water level, that of Lake Valcour, was rapidly recovered and has since been held.

Let us now take the evidence this pebble has to offer concerning the question of cave formation. As it has rested at a level close to that of the floors of many of these caves for just as long a time as Lake Champlain has been in existence, it should be able to offer a fair measure of this lake's capacity to dissolve its limestones and to erode them through dentpit formation. At Cystid point these two agencies have cut comparatively pure limestones to the depth of but 27 millimeters. It does not seem likely that the deeper purer waters of Paradise bay could, in a more sheltered position, have cut to greater depths during the same period. Many of the caves of this region, however, represent a cutting more than 75 times as wide and several hundred times as deep. Portions of their walls are out of water for more than half of each year and are then free from any action of this nature, but the pebble has remained under water for every moment of every year. The results of this comparison are very striking and perhaps are not wholly fair. It may be urged that vortex action would be stronger and therefore more effective in shallower waters. This may be true, but the greater depths of the caves have also been subjected to this action for every moment of every year and under this depth we shall probably be again dealing with vortexes whose strength is no greater than those of the pebbles' level at Cystid point. Most of the cave walls maintain their wedgelike shape and become wider as the limit of low water is reached. Weighing carefully the evidence, we shall make ample allowance for the results of these two features of wall cutting if we credit them with the removal of between 2 and 4 centimeters of surface during the age of the present lake. The evidence of the pebble is therefore to the effect that Lake Champlain has been at most but a modifier of a belt of old caves which were very evidently left here by an ancestral body of water.

Valuable as has been the evidence this specimen has given us, it has yet failed to show that for which it was taken from its position of long rest. In other words it has failed to clearly show the amount of solution accomplished by the present lake. We have merely found a very definite limit which solution could not have reached in the time involved. It should be allowable however, and helpful as well, to make an approximate or tentative estimate of the share each agent has accomplished in this recorded work. As a whole, abrasion is a much more powerful agent than

solution, but we are on very uncertain ground when the abrasive material used is as fine as it must be in this case; and also when its particles are so much freed from the influence of gravity. The practical absence of evidence for differential solution on dentpit surfaces, however, is a very good indication that molar abrasion is here still the most important factor. We may allow it at least two thirds of the 27 millimeters noted. The remaining 9 millimeters will then become an index of an utmost limit for the amount of erosion accomplished by molecular abrasion, solution in presence of a rapidly moving solvent, and solution in a quiet solvent or where molecules and ions can escape from the contact films only by diffusion or movement induced by gravity.

As the rapidly deepening rill channels on roche moutonnée slopes are by themselves strong evidence of the powerful influence of a rapidly moving solvent, and as our previous discussion shows that we should expect it to be such in both this type and in dentpit formation, we may assume that vortex motion through molecular abrasion, through bringing the greatest volume of water in contact with a given surface in a given time, through forceful detachment of portions of saturated contact films and through various transformations of energy, is responsible for at least two thirds of this 9 millimeters, and that quiet normal solution, relying on simple gravity or diffusion to further liberate the molecules which have passed into the contact film of the solvent, is responsible for not more than 3 millimeters of a surface on which it has been acting for 50 centuries or more, which is the time we may temporarily assign for the age of Lake Champlain.

While, therefore, solution may have played a very important part in the formation of these caves, it was very certainly not solution by the waters of our present Lake Champlain.

Additional evidence as to the effects of solution is to be found in Sloop bay. At the foot of a cliff which terminates the horizontal depth of the bay there is exposed a wide glaciated shelf which dips gradually southerly and enters the present waters of the lake. The higher portions of this shelf are still covered by till and show the usual scratched and polished surface of the rock, when uncovered. That portion which has longest been uncovered, save at highest water of spring floods, has been acted upon by expansion of water freezing in its joints and bedding planes, and large blocks have been loosened to be pushed about by shore ice or dragged seaward by ice blocks during the breaking up of the lake in the spring.

As the shelf approaches low water it reaches a level where the action just described is inoperative, and the surface sheet of rock has not been removed. This surface sheet is swept clean of sediment and is much as the ice sheet left it. The bed here had its constituent sediments assorted by vibration of the bottom waters of the Chazy sea, due probably in part to wave motion on the surface and in part to tidal flow of waters over the surface of the sediments. A series of interlocking ridges containing much silicious material were thus segregated and the bottoms of the miniature valleys between filled with the finer and purer calcareous material of the bottom. Solution aided by mechanical attrition has carried away the exposed softer portions of this bed to a depth frequently measuring 24 millimeters and sometimes slightly exceeding this depth. A view of this shelf at a time of low water is shown in plate 17. The ridges remain as flat surfaces of irregular outline. Abrasion has removed the glacial polish and finer striae from these surfaces and there is a slight relief of a fraction of a millimeter in some places which reveals figures like branching algae with stems from 2 to 6 millimeters in diameter. The amount removed from the higher surface can not well be more than 1 or possibly 2 millimeters, the average loss of surface from the softer and harder portions being in the vicinity of 15 millimeters. The bay opens to the east and there are no strong winds from this direction in this region. North or south storms disturb the waters here but very little. The bay however has a muddy bottom and storm action enables its waters to take up enough sediment to become discolored. At such times small and gently moving waves with an abundance of fine abrasive material must lap this area. Careful examination of the lowered surfaces of the rock plainly show the presence of water vortexes carrying silt. The difference between the 55 millimeters of the block last studied and the 24 millimeters of surface removed here must be largely due to the great difference of wave energy in the two localities. Whatever part has been played by solution in the lowering of the Sloop bay surface has been aided in no little measure by plant action for blocks taken from this surface show a dried organic film still attached to the very irregularly pitted surfaces of the depressions. The depth of 24 millimeters is not to be found next the harder ridges but near the middle of the softer area. Solution alone would have worked with greater uniformity. As in even the lesser depths, erosion by vortex action is still a factor, it hardly seems possible that pure solution could have

From a photograph of a rock shelf in Sloop bay, taken during low water on September 29, 1906. The solvent powers of Lake Champlain, aided by mechanical abrasion, have cut the softer portions of this shelf to a distance of between 2 and 3 centimeters below the former glaciated surface.

removed more than a very few millimeters of this surface. Now the periods of time involved in the cutting of the dentpits, the softer layers of the pebble from Cystid point, and the softer layers of the rock shelf here are practically equal, for the phenomena occur along the same horizon. When once the waters of Lake Champlain had reached their present level it would not take shoving blocks of ice very long to clean off the Sloop bay shores and leave them very much as we now find them. The amount of rock surface removed by the solvent action of the incessantly changing, and far from saturated, waters of Lake Champlain is shown by these studies to have been remarkably small.

A still more conclusive bit of evidence concerning solution is to be found along the more southern portion of the west shore of the island. There is a line of low cliffs along a considerable portion of this shore, and it often rises several meters above low water. These surfaces are exposed to wave action from seas raised by westerly winds. Such waves here carry little sediment owing to the deep water and clean rock bottom just off shore. That these waters are deep is indicated by the presence of the ruins of an old dock here at which the largest lake steamers used to stop to take on wood in the days when that was the available fuel. A view of this region is shown in plate 18. The long oval rock basin of the foreground, considerably foreshortened in our view, is but one of a number of such basins cut by the till on the old shore line of Lake Valcour. The debris seen in the basin has been derived from higher portions of the shore line through the effects of freezing water in joints and bedding planes, and the action of shore ice. The amount of the destructive work of Lake Champlain on this older glaciated shore line may be easily seen. The principal, and by far the greatest cause of loss, has been due to the effects of freezing water in joints and bedding planes and the subsequent removal of the loosened blocks through the action of shore ice. The material now lodged in the glaciated basin is a portion of the material which was so derived from the surface above. Wave action itself, even with the load of tools here present, has been rather an unimportant agent and has not been able to modify appreciably the basin in question. A nearly complete portion of an old glaciated outline of this ancient coast may be seen where the figure is present. One block has been removed from the surface on which she is standing but much of the old glaciated surface remains above and to the right of her head. The shelf on which the boat rests has been

somewhat cut by cupholes. The edge of a still older, upper terrace, which Lake Valcour was destroying, may be seen directly above the head of the figure. The old steamboat dock is hidden in the second cove beyond the boat. In plate 19 we have a view in this region taken farther to the north and near the position of the old steamboat dock. Another glacial basin, partly filled with rock debris, is here shown. The rock boss at the right of it has not yet lost its glaciated outlines although freezing water has detached one block from its surface and the movement of shore ice has drawn it a little outward. We have here a practically unbroken glaciated outline reaching from low to high water. While the lake was yet above its present level the side of this boss facing the lake must have lost the sediments with which it may have been covered. Its surface has been exposed to the action of solution throughout the age of Lake Champlain. While the movement of loose material on this surface has destroyed glacial striae yet such striae may be seen on surfaces at the same level just south of this. There are places here that have not lost 5 millimeters from their former polished surfaces and we are obliged to limit the solvent power of the lake waters to a figure at least as low as our estimate made from the study of the pebble taken from Cystid point. If one is still in doubt as to the correctness of this estimate let him examine again the west side of Spoon island as shown in plate 4. The unbroken glaciated surface shown there runs from below lowest water to above highest water After allowing for loss of surface at the hands of various agents active here, what will you have left for simple solution? The well developed caves of plates 1 and 10 lie between 60 and 180 meters from this face and on the same level. What part has solution, at the hands of Lake Champlain, played in their formation?

Before leaving this question of solution we should call more definite attention to an agent we have but mentioned, and that is the influence of living or decaying green algae, sponges and micro-organisms. If we again examine plate 9 we may note that this surface of the Lowville block has a border of dentpits which distinctly show the effects of differential solution brought about by the above cause after the block had fallen from its bed. Nearer the center of the block there was not light enough to support plant life and the dentpits of this region have suffered but little change though there are a few thin seams of less solvent material running through the block that have here formed very

A view of a portion of the southwest shore of Valcour island, showing some of the glaciated outlines of the older shore of Lake Valcour. From a photograph taken in August 1908

View of a portion of the southwest shore of Valcour island from a photograph taken October 16, 1909. Shows a practically unbroken glacial outline from low to high water. The point just beyond the glaciated basin is a part of the wave destroyed, old steamboat dock.

fine and slightly raised lines which follow the rise and fall of the dentpit surfaces. Such elevations on the general relief of this surface are in no case greater than a fraction of a millimeter. This type of solution is due to organic acids produced by resident organic forms, and is chemical in its nature. The cave walls are protected from this agent, save in an indirect way, for they are shielded from light. The lake waters themselves of course hold carbon dioxid in solution and the supply is constant and from various sources. It has no doubt markedly increased the solvent power of Lake Champlain waters but its effects lie within the limit of the 3 millimeters already set as the greatest limit of quiet solution since the recession of the Hochelagan sea.

Effect of expansion of freezing water. We have already called attention to this most powerful of all the disintegrative agents now at work on Valcour island in our remarks covering the features presented by plates 18 and 19. The vertical or overhanging front of the cliff shown in plate 1 is very largely due to this cause. In the *Fourth Report of the Director of the Science Division* [N. Y. State Mus. Bul. 121] plates 5 and 6, will be found two reproductions of this cliff from photographs which I made in the winter of 1903. Both views were taken from the ice surface shown in the foreground, and both contain a view of some portion of the cliff shown in our present plate 1. The ice curtains, which speak of frozen spray, have a very interesting story to tell of cliff destruction. The effect of this agent is here seen to be destroying caves instead of making them. The most numerous and most marked changes in temperature occur on the exposed faces of these walls. The waves break here and wet the surfaces to great hights. The lake waters themselves are rarely frozen over (save for a few days) until some time in January. The fall rains raise the level of the lake and many small cave mouths are covered in consequence. The water in these is never frozen. It is doubtful if the water in the innermost recesses of some of the large caves is ever frozen. Once well within one of the higher caves and we shall find wetting above the water line to be but a fraction of the hight to which it is wet outside. The dentpit etching on the inner wall faces speaks of their comparative permanence, as do also the rounded edges of the rock angles. On the outer face of these cliffs, where blocks have been split by freezing water, no surfaces are etched and all rock corners are sharp. At the south end of the island

where most of the Chazy beds are exposed there are but a few beginnings or remnants of caves in the very beds in which they should abound. The cutting back of the cliff by the process indicated gives the cave-forming forces but little chance to outrun it. On the shore represented in plate 1 the wave energy is much less powerful owing to the projecting capes to the south. Here outer destruction follows inner formation at a respectful distance. At long intervals a fragment of the side wall of the caverns some distance in may become dislodged and plate 11 shows several edges that could be easily removed. A few such have been found in the debris partly filling some of these caves. However large a part this destructive agent may have played with outside walls as we enter the caves its power is reduced with the distance to which we penetrate until finally it is entirely inoperative. It is widening the mouths of the caves somewhat and increasing their hight in some instances but it is doing nothing to carry them deeper into the cliff.

Evidence from preliminary excavation. The floor of Bat cave is deeply covered with blocks which must have fallen in greater part from the roof though doubtless there have been also many contributions from the side walls. An effort was made during low water of the present season to penetrate this mass and find the cave floor. The first blocks removed were very heavy and showed little trace of either solution or erosion. Some of the unmoved blocks of this layer may be seen at the lower left in plate 11. The material we removed was all carried toward the front of the cave and much of it thrown completely out. After getting down about a third of a meter the surfaces of the blocks began to show plainly the effects of differential solution, and at about a half meter this aspect became pronounced. For the next half meter the blocks had to be removed from under water and not a single block was found that showed the least sign of any movement in the mass. As a rule the lower blocks were smaller, but all possessed angular outlines and not one showed a rubbed surface. Some of these lowest blocks had edges so thin as to be easily broken off by the fingers, and all showed differential solution to a very marked degree. One specimen taken from the depth of about a meter was photographed, and a view of it is presented on plate 20. A study of the surface and edges here shown will convince any one that wave motion since the glacial period can have had no effect

Plate 20

From a photograph of a sample stone taken from about a meter below the surface of the material now on the floor of Bat cave. It shows conclusively that no one of these blocks is moved over the surface of another and that the cave is therefore not eroded through any shifting of this material. Specimen in possession of New York State Museum

whatever in moving the mass of material now in the cave. If other evidence were needed we could point out the fact that the dentpits extended down by the side of this debris as far as we made our excavations, and that the raised and sharp edges of intersection of the confluent dentpits were in no manner cut across or worn by any movement of the cave filling. Plate 11 shows a considerable portion of this uncovered face of the wall. The horizontal line a – – a separates the formerly exposed surface from that which we uncovered. The position of the camera was about a half meter above the surface of the filling and this will account for the apparent inclination of the lower lines of dentpits. Not only had no marks been made on this wall by block motion but the wall itself had been cut away from the filling so as to separate one from the other. We hoped to penetrate deep enough to see if this loose material rested on any undoubted glacial deposit but the limit of time available led us to cease further prosecution of this work for the season.

The material taken from the cave filling has itself some valuable evidence to offer. We have already seen that Lake Champlain has had but little effect on its rocky shores so far as pure solution is concerned. The material in this cave filling, at the depth from which the specimen illustrated by plate 20 was taken, shows a very marked amount of solution. An examination of this figure will reveal no trace of vortex action as an assistant factor in the cutting but it does show that the rate of removal depended entirely on the minutest differences in character of the bed material. Apparently no better example of pure differential solution could be desired. If there has been no help from mechanical abrasion, the filling at this depth is most certainly older than Lake Champlain. The absence of movement in the mass on this cave floor and the depth to which solution has acted on the deeper portions of the filling can lead to no other conclusion than that these rock fragments were in the position in which we now find them before Lake Champlain began to cut its present series of cupholes and dentpits.

The westernmost cave of the north wall of Paradise bay was next examined. Plate 21 gives its appearance as seen from the water edge at low water October 23, 1909. This cave is formed on a minor fault plane and close to it, both to the east and west, are parallel faults of small displacement. Freshly fallen blocks from the face of the cliff at (*a*) reveal nearly horizontal slicken-

sides. That there was some horizontal movement together with a slight vertical displacement is also shown by the neighboring faults. The cliff beds are much more fractured here than they are in the region immediately east, which is that shown in plate 1. As a result the cliff face has here receded to the north more rapidly and has left the less fractured face some meters behind. The latter plunges vertically into the water but the more rapidly receding portion has left in front of it a sloping beach which crosses the cave mouth at the cliff line. This recession and the position of the cave, which is well within the bay, both protect it somewhat from the effects of freezing spray though we still have the active work of freezing of water after cold rains in fall and spring and the freezing of water from melting snows. During storms the strong elbow of the cliff protects the recess from the grinding effects of strong wave action, and the fragments on the floor are but little rounded. Probably the fragments now on this shelf are comparatively new, for oblique wave motion would carry the more worn material into the recess at the northwest corner of the bay. Here we do find a mass of material that is all of limestone and has accumulated in this locality since glacial time. The writer first saw this cave in 1898. The following year he camped in its vicinity and converted it into a very serviceable dark room for photographic purposes. One large and well worn stone lay partially within the mouth and this was removed to make the interior easier of access. One had still to enter on hands and knees, though after penetrating to the horizontal depth of about 2 meters, one entered a rather roomy chamber in which several people could stand at the same time. The roof of this chamber is about 3 meters above the floor. Back of this first chamber there is another but the passage between the two is too narrow to allow of entrance. A few blocks were carried into the first chamber to support a board which was used as a dark room table. The waves of the following season moved several large blocks against the opening of the cave but did not disturb the stones placed on the floor of the chamber. For several years blocks have been thrown up in the front of the mouth during spring storms and often one or more has had to be moved in order to gain access to the interior. No large blocks have ever entered to any great distance into the cave. Waves have no doubt thrown smaller wave-worn pebbles over the larger guarding blocks and have moved these back and forth at exceptional times, but such

View of mouth of Darkroom cave and adjacent wall from a photcgraph taken from the lake edge on October 23, 1909. At *a* in the left upper portion we may see horizontal slickensides. The fault plane, on which the cave was cut, shows a slight downthrow on the right. The wall at the right shows for the greater part a surface produced by differential solution.

movement has not been sufficient to effectively cut the cave walls at their level. Material of this nature is also absent from the second chamber.

Late in the summer of 1909 a small excavation was made in the deposits covering the floor of the mouth of this cave. On digging down the size of the pebbles rapidly decreased, and numerous small and well polished granitics and quartzes were found among the limestone pebbles. At the depth of a few decimeters a thin layer of very fine and clean gravel was encountered and immediately under this was a fine and well oxidized clay containing a few pebbles so thoroughly decomposed that the peen of the hammer easily cut them and left half of the pebble imbedded in the undisturbed clay. The boundary between gravel and clay was very sharp and distinct. A block, or a projecting edge from the cave floor, now interfered with making a deeper cut in the small place chosen. The fine oxidized clay and the few thoroughly oxidized pebbles speak very decidedly for a deposit at least as old as that of the Hochelagan sea. We should also state that the buried portion of the cave wall was but a continuation of the exposed portion above. The cutting of the whole cave opening was thus shown to be older than the clay filling, and all subsequent erosion has hardly modified the opening. That this cave in all its essential features is at least as old as the glacial period must be considered as demonstrated beyond the shadow of a doubt.

Miscellaneous evidence. To the east of this cave is another which can be reached by boat or by the sinkhole shown on plate 2. The natural bridge between the sinkhole and the lake consists of badly fractured material. About 500 pounds of this rock were recently detached from its undersurface and allowed to fall to the cave floor in order to insure the safe passage of pupils doing field work in physiography. This cave is also cut along a fault plane parallel with that of Darkroom cave. One slickensided surface, by means of its well preserved diagonal lines, shows that the small vertical displacement (throw) was accompanied by a greater horizontal component. A view of the mouth of this cave has already been seen in plate 1. It is one of the few caves that have had their openings cut to the very top of the cliff. A careful examination of plate 21 will show that the same thing might easily have taken place there but for the fact that the wedge-shaped mass pinched in between the nearly parallel fissures has the smaller edge downward. In Bridge

cave, as we shall call the one we are here discussing, there is a similar wedge-shaped mass but toward the front of the cave the edge of this wedge was uppermost. There is some evidence in this cave that solution began its work on two nearly parallel fissures which were about a meter apart near the top of the cliff but which increased this distance to a little more than 2 meters in descending to the present low water level of the lake. This partition was subsequently cut away in many places. Dentpit action is at work cutting through the separating walls of smaller contiguous caves. Portions of these former separating walls are now left as pillars supporting the roof of a widened cave mouth. This cave has two items of proof to offer concerning its age, which differ from any we have yet mentioned.

Plate 22 shows a portion of the east wall of this cave in the region of the sinkhole. At (*a*) we have a portion of the older face of the wall removed by the action of expanding water in joint planes. The surface thus exposed is not a fresh one but has been subjected to a long period of weathering. We may note a still older surface of similar character under the overhanging mass at the right. At (*b*) we have what we may call an original surface or one not yet acted upon by the agent specified above. The deep etching which the edges of the very irregular bed surfaces have received and the much weathered edges of the finer laminae both speak of very great age, for the position is here a sheltered one. At (*c*) we have a portion of the wall of a cylindrical excavation which appears to have been cut by spirally descending waters. This cylinder opened into a basin which was more deeply cut in the side wall and which plainly speaks of water carrying abrading tools. Note also a portion of the deeply cut basin diagonally above this at the right which also emptied into it. Is any agent so cutting these walls at the present time? One answer to this question is to be found in the filling of this part of the cave for this filling has covered up a large portion of the lower basin and this it could not have done were any such cutting action now present. The filling is talus like and neither deposited nor modified by running water. Another answer and yet the same, is to be found in the appearance of the surface at (*c*) which shows its etched, irregular bed edges and its laminae nearly as plainly as at (*b*). The slight difference between these two surfaces is due to the fact that the recessed surface at (*c*) is now better protected, from even getting wet, than is the surface at (*b*). The very slight drainage this cave may now receive from rainfall or melting snows has had nothing whatever

Plate 22

View of a portion of the east wall of Bridge cave near the sink hole.
From a photograph taken November 2, 1909

to do with the erosion of the larger features here shown. The large chamber of Darkroom cave shows the same type of cutting by falling and whirling waters carrying abrasive material. No water whatever now enters the upper portion of this chamber. An examination of plate 22 will show that the descending streams which must have done this work were reflected and thus turned from one place to another either along the fissure plane or from one wall to its opposite. The shallow nature of the cut at (*c*) and the deeper cuts at the right of it and below it are due to such reflections of the falling stream. These caves present many other examples of the same nature and the evidence, in all its varied features, is wholly against any such cutting at the present time and wholly for a cutting which must have taken place many thousands of years ago. All of the cuts and the great chamber in Darkroom cave with its horizontal and cylindrical outlet, point irresistibly to the conclusion that we are here dealing with glacial moulins cut in older rock fissures.

This conclusion however opens up another field of great interest. At the time of the melting of the later Wisconsin ice sheet the rocks of Valcour island had been so far depressed by isostasy as to bring their highest portions below the level of the sea. If the caves had been modified by glacial drainage at that time, the waters passing through these caves must have completely filled every portion of them and been moved under great pressure. The leaping of such a drainage stream from side to side, cutting now more in this place and again in that (and cutting as if falling freely) would be out of the question. The effects could not have been so markedly localized as we now find them to be; but would have been of a larger and more uniform type. In order to find conditions that would yield the effects we have here noted we are compelled to go back to a time when the land was at least as high as it is at present. It is quite possible that we have in these cases a witness of moulin action at least as old as the earlier Wisconsin stage, if not older.

The next new item of proof offered by Bridge cave comes from an examination of its northward extension. The entire cave roof (the wedge between the two fissures) has been thrust down and fractured, as the result of great pressure above. A depression on the surface of the ground over the cave can be seen to run many meters to the north although now covered with soil and overgrown by trees and bushes. The only agent that could have forcefully thrust down this wedge is glacial ice.

A unique but important bit of evidence is found in the west wall of the narrow channel separating Spoon island from Valcour island. A rather high rocky promontory runs about east-northeast some 450 meters from the inner beach of Spoon bay. A block about 50 meters wide, cut off from the end of the promontory by a north and south fault, has been converted into an island, namely Spoon island, by erosion along the fault plane. Since the rocks dip southerly, and as the downthrow was on the east, Spoon island has apparently been shifted 100 meters to the north and forms a distinct barrier to currents moving easterly along the south wall of the bay. The imprisoned glacial ice and till of the Spoon bay basin would thus find their nearest and lowest southerly outlet lying along this fault channel, which is about 30 meters wide with high and nearly vertical walls on either side. The ice and till finding its exit here would be forced through under great pressure.

The northerly position of Spoon island with reference to the present end of the promontory soon allowed the till stream a free passage across the south end of the island to deeper and freer channels, and this eastward deflection was hastened by a well marked buttress on the middle of the east wall of the promontory.

That this buttress has been subjected to great pressure from the north is clearly shown by nearly horizontal pressure joints which cut diagonally across the beds and curve upwards as one follows them southerly. The caves shown in plate 10 lie just south of this buttress, and they must have been protected by it in a very marked degree. The rather small and northernmost member of this series of caves is located in the base of the buttress itself, and the pressure received by its northern wall was great enough to dislodge from it a rectangular block weighing some 300 pounds and thrust it southerly and inward against a filling of till. As the bottom of this cave lies some distance below the surface of low water, while its top is completely covered by high water, the finer material of its glacial contents has been washed away. The thrust-in block, however, still holds a number of imprisoned, glaciated limestone pebbles the size of cobblestones. As the upper and narrower portion of this cave is thus shown to have been filled with glacial till, we are again forced to conclude that all of the caves of this series are preglacial and that they have been but slightly modified since glacial times.

This cave offers very valuable evidence as to the solvent powers of Lake Champlain. Although it occurs in the purer dolomitic lime-

stones of the Chazy beds, postglacial waters have not cut back its walls to an extent that will yet allow the removal of the imprisoned pebbles. The block offers still more conclusive evidence, for though slight movements have enabled it to grind its own lower surface and the bed on which it rests, thus allowing water to have free access to its other surfaces, it has suffered but slight loss in size since glacial time. We have thus an additional proof which supports strongly our contention from other evidence that the present lake, through simple solution, has not removed material from its exposed limestone surfaces to a depth exceeding 3 millimeters.

There is yet another aspect from which we may view this cave question. Wherever the purer Chazy beds are exposed on the surface of Valcour island their unfilled master joints or fissures will be found to have suffered in varying degrees by solution and chemical action at the hands of surface waters. In some places these joints have been so widened along considerable portions of their length as to freely admit the leg of a man. In other places we may find joints whose faces seem to meet at the surface while they are separated in their deeper portions. Along such joints we find open circular holes in some instances small and close together and in other instances so large as to freely admit one's leg. I have been told that holes of this type have sometimes broken the legs of cattle, and I have noticed that many of these have been artificially filled or covered.

These dissolved joint crevices extend to depths of some 20 meters or more (65 feet and over). In Sloop bay, where a portion of the north wall has been quarried, these joint openings are seen to widen out into chambers which plainly show the effect of swiftly moving waters. Such opened joints with their inner chambers are often accessible to foxes and many of them have been used as dens.

We are now prepared to face a new problem. If our faith in the power of solution is great enough to allow us to conclude that surface drainage has accomplished all of this extensive joint opening since these rocks emerged from the Hochelagan sea, we must also conclude that during the longer periods of exposure which preceded the approach of the Wisconsin ice sheet joint crevices would have been acted upon by similar agencies, been cut down to former base levels and widened out into chambers far surpassing in size those now existing in this region. These two conclusions involve the making of a third as follows: To remove every trace

of these older joint channels (for our first conclusion asserts that the present ones are all new) we must further conclude that the Wisconsin till sheet cut away the tops of these isolated limestone hills to a depth even greater than the 20 or more meters now occupied by the existing system of joint channels. Now this third conclusion is one that can not be maintained and with it the first also falls. There seems to be good and abundant evidence that these hill tops were cut away by recent glacial action to a depth that rarely exceeded 2 meters, and even though we should allow more than five times that amount we should still expect to find the widened bases of the joint channels of the older period. Joint solution through the action of precipitated waters is an exceedingly slow process, and all that post-Hochelagan precipitation has been able to accomplish is a washing out of sediments accumulated during the recent period of submergence, and a very slight enlargement of the older channels. As the shore line caves are for the greater part but modifications of these old joint channels the preglacial origin of the one implies also the preglacial beginnings of the other.

The varied and cumulative evidence here presented seems to the writer to amply warrant the conclusion that both joint channels and caves are, in their larger features, preglacial. A few words concerning their origin may assist in more clearly comprehending the questions involved.

Origin and development

Where locally elevated regions have been unable to maintain a mantle of soil the surface rock is subjected to more rapid changes and greater extremes of temperature than where such a mantle has been allowed to accumulate. The effect of such changes tends not only to develop and maintain joint crevices, but it opens them at the end of the winter's cooling more widely and to greater depths than can occur in covered regions. At or soon after the time of widest and deepest opening the waters from melting snows and spring rains enter with great freedom, and after passing rather rapidly through them exit at lower levels thus quickly emptying all spaces not kept full by capillary attraction. These spring waters with a temperature of nearly zero degrees would contain more abundant carbon dioxid than summer waters, for the snow mantle of winter absorbs this gas not only from the air above but from the fracture zone below. The period of widest open crevices would

therefore coincide very closely with the period of most abundant flow of chemically active water. The deeper and narrower portions of crevices kept full by capillary attraction would lose no appreciable amount of water by evaporation on account of the small and protected exposed surface. Such waters while they might approach saturation would rarely reach it because each fresh filling of the space above the water surface maintained by capillarity would add mechanical pressure and force the older water out at lower levels, thus refilling the crevice with fresh water. As the expansion of the beds during the summer heating forced the crevice walls more closely together, a portion of the water held by capillary attraction would be forced to occupy new positions and would take its dissolved load with it. Evaporation would rarely be rapid enough to allow of deposit and the occasional advent of summer rains would furnish abundant fresh water and help to remove that more nearly approaching saturation. Fall cooling and the more abundant rain of that season in this locality would be very effective agents in removing material dissolved during the summer.

Exposed joint crevices, so situated as to receive surface flow, are thus gradually widened and deepened. Other joint crevices connecting with these might not receive so much water directly from the surface but they would help to carry the subterranean flow and become also widened. As the system developed the waters would move in certain channels with greater freedom. Dust and disintegrated particles accumulating on the exposed rock surface would be swept by rainfall into these openings, and the effects of abrasion would be added to those of solution. Joint crevices thus become joint channels. As these are widened they admit the cold air of winter in greater volume and the circulation maintained at this season serves to more effectively chill the rock mass and thus open the crevices to greater depths. As these channels approach local grade (determined by the level of a surrounding body of water or by the water table of the mantle rock flanking these regions) the deepening of the crevices ceases, but lateral cutting is continued. Such basal widening of the system is an indication of maturity.

Such work must be exceedingly slow, for the water supply is only such as falls on the very limited area in question. The waters doing the work would be free from humus acids on account of the bare character of the rock surface. Expansion of freezing water would be effective near the surface, but the depth at which it could be considered as an important factor would be very limited.

If the temporary base level was determined by a surrounding body of fresh water, as it appears to have been in the case of the Valcour island elevation, the exits of the joint channel system of drainage would be under the influence of a greater number of erosive agencies than the inland portions of the same system. Solution would be incessant, the solvent would be always in motion, and it never could approach a condition near saturation. The presence of light would permit the growth of lowly organized plants and animals, and their metabolic processes while living and their decay at death would both favor the process of chemical solution. If we will compare the effects of simple quiescent solution by thin water films approaching saturation with the effects of chemical and mechanical solution by incessantly acting and constantly moving waters of great volume, we shall see that this difference in erosive power would of itself turn joint-channel exits into water-level caves. To this means of differentiation we must add the influence of wave motion. This agent does work of very varied character from that accomplished through sliding or rolling of heavy blocks or the throwing of pebbles taken temporarily into suspension, to the work of broken wave vortexes holding solid particles so fine as to be almost in a state of permanent suspension. The submerged condition of the cave floors on Valcour island has protected them from the more energetic types of wave erosion, but the effects of vortex work are very manifest. Expansion of freezing water in these joint-channel exits is also a factor productive of widening. As a result of these agents of erosion the joint-channel exits become caves which narrow toward their roofs and rapidly narrow to channel dimensions as they enter the rock mass.

While the foregoing discussion outlines the probable history of formation of the larger shore-line caves of Valcour island, it does not account for the formation of the majority of the smaller openings for these do not seem to be connected with joint channels.

If a narrow joint crevice, so situated as to receive little water from rainfall in its higher portions, is bathed below by lake waters, such waters will tend to fill the crevice by capillary attraction but will at the same time receive all dissolved material and tend to maintain a fresh-water filling. As the lower portion of the crevice is thus widened the hight to which the water filling is maintained is lessened, but a new factor comes into play, for the effect of wave pressure in filling and emptying the crevice becomes now more pronounced and allows of more rapid changes in the filling. So soon as the breach becomes wide enough to permit water vortexes

to act on its walls, dent-pit action commences, and all other local agencies become more effective. As these caves thus work their way back from the coast line the air in them is at times compressed by storm waves which break against and cover their mouths. A large portion of this compressed air thrusts out a volume of water at the upper portion of the cave mouth with great violence, and the tops of these spouting caves are thus cut into the form of an arch. A portion of this air, however, with its contained hundreds or thousands of dust particles per cubic centimeter[1] must be discharged backward into the open joint crevice with considerable initial speed and thus serve to widen its proximal portions and allow freer entrance of water to these portions at times of high water.

Joint channels and joint caves were more or less modified during the last glacial period. With the advent of this period the outer portions of the rock mass were gradually lowered in temperature, and a condition of permanent frost came to occupy the joint channels. These were thus filled with ice before surface movement of the ice sheet became an effective erosive agent. In many localities in the glaciated regions of North America there are deep fissures or cavernlike openings which were so filled and which still contain glacial ice. The ice filling of these joint channels saved them from being filled with mantle rock when the ice movement began and saved them also from a later filling of till, though they received a till covering. The loss of material from the underside of some of these till coverings is now made manifest by a sinking surface over certain joint channels or by small sink holes like that shown in plate 6.

At some time during the glacial period subglacial drainage must have been comparatively free on surfaces now some 600 feet below the highest level of Lake Vermont (Glacial Lake Champlain)[2] else it is hard to conceive how giant kettles and rill channels (cut by surface flow of glacial waters) could be now found in this lower region. During such a time of elevation (at least to a degree as high as the present) subglacial waters found their way into wide joint channels through narrow surface openings and these were rapidly cut into circular shape by spirally descending waters. Some of the larger caves were thus occupied for a brief period by rap-

[1] *See* Aitken, J. On the Number of Dust Particles in the Atmosphere. Roy. Soc. Edin. Trans. 35:1 (1888); *see also* Nature, 37:428 (1888), 40:394 (1890).

[2] *See* Woodworth, J. B. Ancient Water Levels of the Champlain and Hudson Valleys. N. Y. State Mus. Bul. 84, p. 195.

idly moving subglacial streams and their walls still show the effect of these moulins [*see* pl. 22].

The old relation of these joint channels to surface drainage has also been in part changed by glacial erosion, for wide open channels may be often found where they now receive little surface drainage, and undrained surface basins may occur at no great distance from them.

The movement of the till sheet along the east and west sides of Valcour island has modified many cave mouths, cutting away more from the lower portions of their southern walls than from their northern walls and thus leaving the latter the more nearly vertical. This effect may be seen in some of the wider cave mouths shown in plate 3. A moving till sheet would also cut away more rapidly at the cave mouth level, where caves were numerous, and thus tend to leave overhanging or convex faced cliffs, such as may be found on the east side of Spoon island.

During the occupancy of the region by Lake Vermont and the Hochelagan sea these joint channels and caves where not protected by an undisturbed till sheet were in part filled by fine though rather rapidly deposited sediments, and the whole tendency of these two stages was toward the preservation of the erosive work already accomplished rather than toward the inauguration of any new cutting of the old channels or cave recesses.

With the beginning of the Lake Champlain stage these old joint channels served again, though in a modified manner, their ancient function and the lake waters began an attack on the old cave mouths. This stage has existed for so short a time, geologically speaking, that it has produced but slight changes in the character of the older features.

It is becoming more and more manifest that the work accomplished by the last glacial period, although vast and tremendously impressive, did not obliterate so much of a former surface history as many geologists have been inclined to believe. Glaciated regions must be likened rather to a palimpsest from which a large portion of the older story may be recovered, and much work in this direction remains to be accomplished.

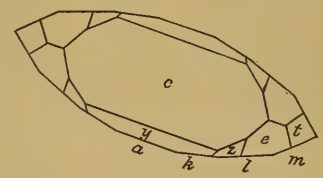
CONTRIBUTIONS TO MINERALOGY

BY H. P. WHITLOCK

Brookite

Indian Ladder, Albany co.

Brookite from a new locality in the Helderberg escarpment was noted on a specimen of calcite collected by Mr C. A. Hartnagel. Subsequent examination of the locality resulted in the collection of a suite of specimens of calcite which yielded on solution 10 small crystals of this mineral. The calcite vein from which these were obtained is situated at a point about half way up the cliff about 2 miles south of Meadowdale and ½ mile east of the road which ascends the escarpment from the latter village.



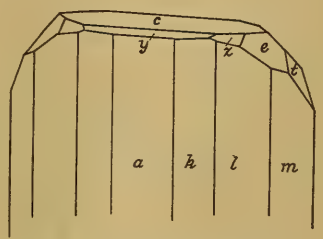


Fig. 1 Bookite, Indian Ladder

The crystals are minute, measuring from 1 millimeter to .5 millimeter in length. They are in every instance brilliant, with sharp, well defined faces and in general habit resemble those from Ellenville, Ulster co., N. Y. Figure 1 a and b shows the prevailing crystal habit. The vertical zone is much striated, due apparently to the development of vicinal prismatic forms. The following forms were noted on the seven crystals which were measured:

a(100), c(001), k(410), l(210), m(110), y(104), t(021), z(112) and e(122).

The following measurements served to identify the forms:

LETTER	ANGLE	NUMBER OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
m : m′ . . .	110 : $\bar{1}10$	13	99	46	99	50
l : l′	210 : $\bar{2}10$	9	134	21	134	21½
k : k′	410 : $\bar{4}10$	10	155	54	156	14
c : y	001 : 104	7	15	37	15	40
c : t	001 : 021	15	62	5	62	6
z : z‴ . . .	112 : $1\bar{1}2$	4	44	25	44	46
z : z′	112 : $\bar{1}12$	6	53	44	53	48
e : e‴ . . .	122 : $1\bar{2}2$	4	78	38	78	57
e : e′	122 : $\bar{1}22$	5	44	19	44	23

Fluorite

Rossie, St Lawrence co.

Among the specimens in the New York State Museum collection is one worthy of notice, collected by the late Prof. Ebenezer Emmons, from Rossie, St Lawrence co. This specimen which measures 9 by 5 centimeters consists of a mass of rhombohedral calcite on which are implanted several compound crystals of fluorite of unusual habit.

These latter are built-up aggregates, roughly octahedral in shape, composed of minute individuals of hexoctahedral habit grouped in parallel position. The octahedral angles of the aggregates are in every case terminated by well developed superposed hexoctahedral crystals as shown in figure 2. The compound crystals are

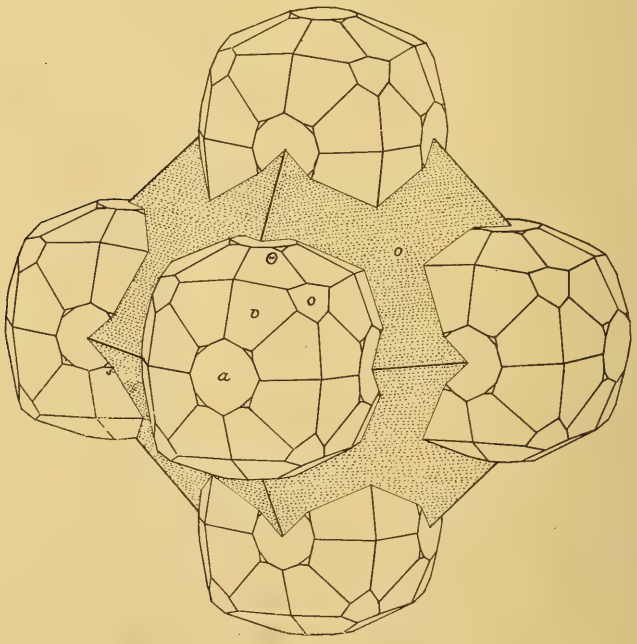


Fig. 2 Fluorite, Rossie

transparent, light green in color and average 15 millimeters in diameter. They are evidently of the same generation as the calcite in which they occur and are associated with chalcopyrite in well developed crystals. Measurements on three isolated crystals yielded the following forms: a(100), o(111), v(731) and

Θ(19.1.1). The last is new to the species. The faces, with the exception of those of o(111), are sharp and brilliant. The planes of the new trapezohedron Θ(19.1.1) show a slight tendency to develop unsymmetrically in opposite pairs with respect to the axes of tetragonal symmetry. In several instances reddish violet spots of cubic outline were noted in the center of the hexoctahedral crystals. The following measurements served to identify the forms v(731) and Θ(19.1.1):

LETTER	ANGLE	NUMBER OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
v : v.....	731 : 713	4	20	39	21	13
v : v.....	731 : 731	5	15	6	14	57
v : v.....	731 : 371	4	42	53	43	12¾
a : Θ.....	100 : 19.1.1	4	4	13	4	15

Magnetite

Split Rock, Essex co.

Among the specimens collected in the summer of 1907 by Prof. James F. Kemp of Columbia University, was one from the Split

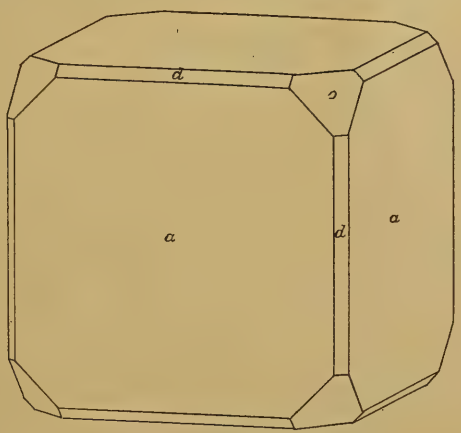


Fig. 3 Magnetite, Split Rock

Rock iron mine which proved to be of special interest. Through the courtesy of Professor Kemp this specimen has been placed at

the disposal of the writer for study. The specimen consists of a mass of titaniferous magnetite forming portion of a joint plane in the ore body. The surface of the joint is covered with small crystals of magnetite of cubic habit closely associated with wernerite in small transparent crystals. The comparative rarity of the cubic crystal habit in connection with magnetite[1] together with the adaptability of these crystals to measurement, has rendered advisable the following brief note:

The magnetite crystals which average 2 millimeters in diameter are exceptionally brilliant, well developed and free from distortion. The simpler combination which is shown in figure 3 consists of the cube a(100) developed to a dominant crystal habit and modified

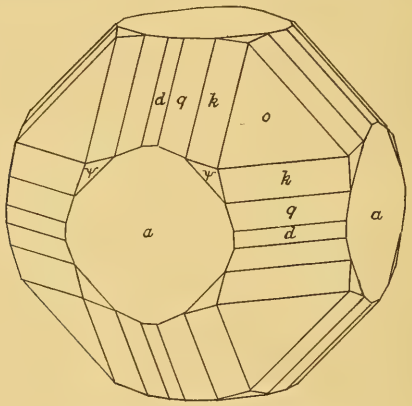


Fig. 4 Magnetite, Split Rock

by the octahedron o(111) and the dodecahedron d(110), both of these latter forms being present in small development. A more complex combination is shown in figure 4 and consists of the above forms developed to about equal habit and modified by the trigonal trisoctahedrons q(331) and k(552) and by the new trapezohedron $\psi = 707 = (711)$. They lie well in zone, the faces of the trigonal trisoctahedrons and of the dodecahedron being markedly striated parallel to the zone [100.110]. The planes of the trapezohedron $\psi(711)$ are small but extremely bright and give excellent reflections. The forms were identified from measurements obtained from five of the best crystals.

[1] Magnetite crystals of cubic habit were noted by H. Sjogren from Mossgrufva, Nordmark. Bul. Univ. Upsala. 1894–95. 2.63.

LETTER	ANGLE	NUMBER OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
o : d.....	111 : 101	12	35	19	35	16
o : q.....	111 : 133	8	22	1½	22	0
o : k.....	111 : 255	9	19	4	19	28
$\psi : \psi'''$....	711 : 7$\bar{1}$1	2	16	2	16	6
a : ψ.....	100 : 711	12	11	17	11	25½

Gypsum

Garbutt, Monroe co.

Among a number of specimens collected in the spring and summer of 1909 from the gypsum region of western New York by Mr Henry Leighton, assistant in economic geology, was a suite of 12 specimens of crystallized gypsum which furnished crystals comparatively rich in forms. The specimens in question were collected from the mine of the Garbutt Gypsum Co., and from No. 2 mine of the Lycoming Calcining Co., both situated at Garbutt, Monroe co. The gypsum crystals occur in narrow seams in massive gypsum and are sometimes associated with crystalline sulfur of remarkable purity and transparency. The crystals are colorless, transparent and average 5 millimeters in length parallel to the positive unit pyramid. In crystal habit, they conform closely to the type shown in figure 5. The prismatic zone is particularly rich in forms, yielding 8 of the 12 prisms recorded for gypsum.[1] Two rare negative pyramids in the zone [010.101] were noted, present either together or alternating on all 12 of the crystals measured. These

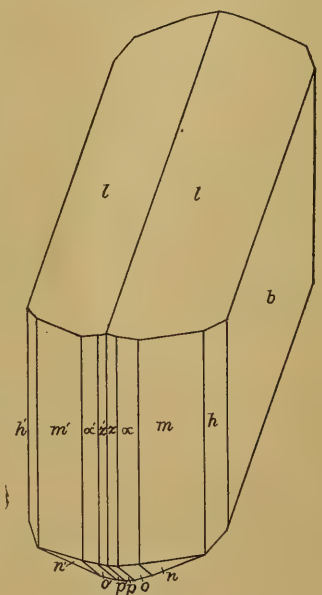


Fig. 5 Gypsum, Garbutt

[1] Goldschmidt, V. Krystallographische Winkeltabellen. Berlin 1897. Luedecke, O. Minerale des Harzes. Berlin 1896. 377.

gave goniometer readings which corresponded to the indexes ($\bar{2}12$) and ($\bar{3}13$). The letters o = ($\bar{2}12$) and p = ($\bar{3}13$) have been assigned to these forms. The distribution of the occurring forms is as follows:

LETTER	SYMBOL	CRYSTAL											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
a	100	...	x	x	...	...	...	x	...	...	x	x	x
b	010	x	x	x	x	x	x	x	x	x	x	x	x
z	310	...	...	x	x	x	x	x	x	x	x	...	x
α	210	x	x	x	x	x	x	x	x	x	x	...	...
Ψ	320	...	...	...	x	x	x	...	...	x	x	...	...
f	110	x	x	x	x	x	x	x	x	x	x	x	x
g	230	...	...	...	...	x	...	...	...	...	x	...	...
δ	350	...	...	...	x	...	...	...	...	...	...	...	...
h	120	x	x	...	x	x	x	...	x	x	x	...	...
k	130	...	...	...	...	x	x	...	x	...	x	...	...
l	111	x	x	x	x	x	x	x	x	x	x	x	x
n	$\bar{1}11$	x	x	x	x	x	x	x	x	x	x	x	x
o	$\bar{2}12$	x	x	...	...	x	x	x	x	x	x	...	...
p	$\bar{3}13$	x	...	x	x	x	...	x	...	x	x	x	x

The following measured angles served to identify the forms; the theoretical angles are calculated from the elements given by Beckenkamp[1] and adopted by Goldschmidt in his Krystallographische Winkeltabellen.

a :b :c = 0.4133 :1 :0.6895 $\quad \beta = 98° \ 58'$

Summary of measured and calculated angles

LETTER	ANGLE	NUMBER OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
b : a	101 : 100	5	90	$\frac{1}{2}$	90	0
b : z	101 : 310	10	77	11	77	$12\frac{1}{2}$
b : α	101 : 210	17	71	13	71	$11\frac{1}{2}$
b : Ψ	101 : 320	5	65	41	65	35

[1] Zeitschr. f. Kryst. 1882. 6: 450.

Summary of measured and calculated angles—(*continued*).

LETTER	ANGLE	NUMBER OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
b : f.....	101 : 110	16	55	43	55	44½
b : g.....	101 : 230	2	44	46½	44	23½
b : δ.....	101 : 350	2	41	53½	41	22½
b : h.....	101 : 120	14	36	35	36	17
b : k.....	101 : 130	4	26	3	26	5
b : l.....	101 : 111	7	72	1	71	50
b : n.....	101 : $\bar{1}11$	20	69	19½	69	20½
b : o.....	101 : $\bar{2}12$	12	79	15½	79	19½
b : p.....	101 : $\bar{3}13$	13	83	2	82	50
f : l.....	110 : 111	4	49	12	49	16
f : n.....	$\bar{1}10$: $\bar{1}11$	5	59	4	58	59
z : p.....	$\bar{3}10$: $\bar{3}13$	5	64	58½	64	55

THE IROQUOIS AND THE STRUGGLE FOR AMERICA

ADDRESS BY ELIHU ROOT, SENATOR FROM NEW YORK, AT THE TERCENTENNIAL CELEBRATION OF THE DISCOVERY OF LAKE CHAMPLAIN.[1]

It is no ordinary event that we celebrate.

The beauty of this wonderful lake, first revealed to the eye of civilized man by the visit of Samuel de Champlain three hundred years ago; the powerful personality, noble character, and romantic career of the discoverer; the historic importance of this controlling line of strategic military communication, along which have passed in successive generations the armies whose conflicts were to determine the control and destinies of great empires; the value to Canada and to the United States of this natural pathway of commerce; the growth and prosperity of the noble states that have arisen on the opposing shores; their contributions to the wealth of mankind, to civil and religious liberty, to the world's progress in civilization — all these, withdraw the first coming of the white man to Lake Champlain from the dull and uninteresting level of the commonplace, while comparative antiquity, so attractive and inspiring to the people of the New World, lends dignity and romance to the figures and the acts that have escaped oblivion through centuries.

Even a dull imagination must be stirred as it dwells upon the influence which the events attending the discovery were to have, upon the issue of the great struggle between France and Great Britain for the control of the continent; the struggle between the two white races for the opportunity to colonize and expand, and between the two systems of law and civil polity, for the direction and development of civilization among the millions who were to people the vast region extending from the Atlantic to the Pacific and from the Rio Grande to the frozen limits of the north.

Authentic history records that late in June 1609 Champlain, accompanied by several white companions and by a great array of Algonquin Indians of the St Lawrence valley, left the French station on the site of the old Indian village of Stadacona, where now stands the city of Quebec, upon an expedition intended by the

[1] This illuminating address, publicly given before a distinguished audience, at Plattsburg, July 7, 1909, is here reprinted in order to give it as wide circulation as possible among the people of the State.

Indians for war and by the whites for exploration. They proceeded in canoes up the St Lawrence and turned south into the Richelieu, and in the early days of July after many vicissitudes and the desertion of the greater part of the Indians they dragged their canoes around the rapids of the river and came to the foot of the lake on whose shores we stand. They proceeded up the lake with all the precautions of Indian warfare in an enemy's country. As they approached the head of the lake they rested concealed by day and urged forward their canoes by night. At last, in this month of July three hundred years ago, they came upon a war party of the Iroquois. Both parties landed in the neighborhood of the present Ticonderoga and with the coming of the dawn joined battle. Protected by the light armor of the period Champlain advanced to the front in full view of the contending parties, and as the Iroquois drew their bows upon him he fired his arquebus. One of his white companions also fired. The Iroquois chief and several of his warriors fell killed or wounded, and the entire band amazed and terror stricken by their first experience with the inexplicable, miraculous and death-dealing power of firearms fled in dismay. They were pursued by the Algonquins, some were killed, some were taken prisoners, and the remainder returned to their homes to spread through all the tribes of the Iroquois the story that a new enemy had arisen bringing unheard of and supernatural powers to the aid of their traditional Algonquin foes. The shot from Champlain's arquebus had determined the part that was to be played in the approaching conflict by the most powerful military force among the Indians of North America. It had made the confederacy of the Iroquois and all its nations and dependencies the implacable enemies of the French and the fast friends of the English for all the long struggle that was to come.

A century or more before the white settlement five Indian nations of the same stock and language under the leadership of extraordinary political genius had formed a confederacy for the preservation of internal peace and for common defense against external attack. Their territories extended in 1609 from the St Lawrence to the Susquehanna; from Lake Champlain and the Hudson to the Genesee, and a few years later to the Niagara. There dwelt side by side the Mohawks, the Oneidas, the Onondagas, the Cayugas and the Senecas in the firm union of Ho-de-no-sau-nee — the Long House of the Iroquois.

The Algonquin tribes that surrounded them were still in the lowest stage of industrial life and for their food added to the

spoils of the chase only wild fruits and roots. The Iroquois had passed into the agricultural stage. They had settled habitations and cultivated fields. They had extensive orchards of the apple, made sugar from the maple and raised corn and beans and squash and pumpkins. The surrounding tribes had only the rudimentary political institution of chief and followers. The Iroquois had a carefully devised constitution well adapted to secure confederate authority in matters of common interest, and local authority in matters of local interest.

Each nation was divided into tribes, the Wolf tribe, the Bear tribe, the Turtle tribe, etc. The same tribes ran through all the nations, the section in each nation being bound by ties of consanguinity to the sections of the same tribe in the other nations. Thus a Seneca Wolf was brother to every Mohawk Wolf, a Seneca Bear to every Mohawk Bear. The arrangement was like that of our college societies with chapters in different colleges. So there were bonds of tribal union running across the lines of national union, and the whole structure was firmly knit together as by the warp and woof of a textile fabric.

The government was vested in a council of fifty sachems, a fixed number coming from each nation. The sachems from each nation came in fixed proportions from specific tribes in that nation; the office was hereditary in the tribe; and the member of the tribe to fill it was elected by the tribe. The sachems of each nation governed their own nation in all local affairs. Below the sachems were elected chiefs on the military side and Keepers of the Faith on the religious side. Crime was exceedingly rare; insubordination was unknown; courage, fortitude and devotion to the common good were universal.

The territory of the Long House covered the watershed between the St Lawrence basin and the Atlantic. From it the waters ran into the St Lawrence, the Hudson, the Delaware, the Susquehanna and the Ohio. Down these lines of communication the war parties of the confederacy passed, beating back or overwhelming their enemies until they had become overlords of a vast region extending far into New England, the Carolinas, the valley of the Mississippi and to the coast of Lake Huron.

They held in subjection an area including the present states of New York, New Jersey, Pennsylvania, Delaware, Maryland, Ohio, Kentucky, West Virginia, Northern Virginia and Tennessee, and parts of New England, Illinois, Indiana, Michigan and Ontario. Of all the inhabitants of the New World they were the most terrible

foes and the most capable of organized and sustained warfare, and of all the inhabitants north of Mexico they were the most civilized and intelligent.

The century which followed the voyages of Columbus had been for the northern continent a period of exploration and discovery, of search for gold and for fabulous cities and for a passage to the Indies, of fugitive fur trade with the natives, of fisheries on the banks and of feeble, disastrous attempts at occupation, but not of permanent settlement. Ponce de Leon and De Soto and Verazzano, Cartier and the Cabots and Drake and Frobisher and Gilbert and Gosnold, had brought the western coast of the Atlantic out from the mists of fable, but they had left no trace upon its shores. Jean Ribaut and his French Huguenots had attempted to do for their religion in Florida what the Pilgrims did in the following century on the coast of Massachusetts, but their colony was destroyed with incredible cruelty in the name of religion by the ferocious Spaniard, Menendez, and the colony of Menendez was in turn destroyed by the Gascon de Gourgues, save a feeble remnant on the site of St Augustine. Raleigh with noble constancy and persistency had wasted his fortune in repeated and vain attempts to establish a colony in Virginia. On the sites of the modern Quebec and Montreal, at Tadousac, at the mouth of the St Croix and at Port Royal, Jacques Cartier and Roberval, Pontgravé and De Monts, Poutrincourt and Lescarbot had seen their heroic and devoted efforts to establish a new France brought to naught by cold and starvation and disease. In that month of July 1609 in all the vast expanse between Florida and Labrador no settlement of white men held its place or presaged the coming of the future multitude save at Jamestown behind the Capes of Virginia, where Christopher Newport's handful of colonists had barely survived two years of privation, and at Quebec, where the undaunted Pontgravé and Champlain only one year before had again gained a foothold. At Jamestown the mournful record of the winter of 1609 to 1610 shows us that in the spring but sixty of the colonists were living. At Quebec twenty-eight Frenchmen with Champlain had braved the rigors of a Canadian winter, and in the spring of 1609 but eight remained alive.

In this same month July 1609 the Half Moon of Henry Hudson was repairing damages in Penobscot bay after her voyage across the Atlantic, and preparing to sail on to the noble river that still bears her commander's name.

The field was open; the hands upon the margin that reached out

to grasp control seemed few and feeble, but the period of preparation was past. The mighty forces that were to urge on the most stupendous movement of mankind in human history had already received their direction. The time was ripe for the real conflict to begin, and it had its momentous beginning when the chief of the Mohawks fell before the arquebus of Champlain at Ticonderoga.

The conditions which limited the powers and directed the purposes of the various countries of Europe in the early years of the seventeenth century made it inevitable that the struggle for American control should ultimately become a single combat between France and Great Britain.

It is true that Spain had overturned the tribal government of the Aztecs and held possession along the northern shores of the Gulf of Mexico, a vantage ground from which she might well have pressed to the northward successful plans of occupation. But Spain had no such plans. When the search for treasure had failed, and it was plain that no more Perus and Mexicos were to be found, the dark forests of the north Atlantic offered no attractions to the Spanish Conquistadores who sought the spoils of conquest rather than the rewards of labor.

With the death of Philip the Second the decline of Spanish power had already begun. His successors were feeble and incapable. The stern, repressive and despotic control over body and soul effected by the union of military and religious organization during the first century of United Spain was accompanied by a marvelous efficiency and energy that made Spain for a time the foremost maritime and colonizing power of the world. The price of that efficiency, however, was the loss of the only permanent source of national energy, the independence and free initiative of individual character among her citizens. Thenceforth Spain was no longer to sway the rod of empire, but holding it weakly in feeble hands was to lose one by one the world-wide possessions of Charles the Fifth and Philip the Second, until the time when the penalty of her national sin against civil and religious freedom should have been paid and the native strength and nobility of her character should be able to reassert themselves in a period of renewed growth and reestablished power and prosperity; a time which we hope and trust has already come.

Portugal, still clinging to the fruits of her explorers' genius, and sturdy Holland, strong in her newly won freedom, were looking not to North America but to Brazil and to the Orient for their opportunities to expand, and the future colony of New Amsterdam

was destined to be readily transferred to the English for the sake of greater opportunities to the Dutch East India Company.

Germany was not yet a maritime power. Loosely compacted under the failing hegemony of the House of Austria she was upon the threshold of the Thirty Years' War, in which the most frightful slaughter and devastation were to destroy her cities, lay waste her fields, reduce her population from thirty millions to twelve millions, and set back her civilization for centuries.

Into that vortex of destruction Sweden also was about to be drawn, and her forces were to be engrossed in the struggle for national existence, so that the hopes of Gustavus Adolphus for a New Sweden upon the banks of the Delaware were to fail of fruition, and the Swedish colony in America was to pass with hardly a struggle into the hands first of the Dutch and then of the English.

Prussia was a dependent dukedom. Russia had still three quarters of a century to wait before Peter the Great was to begin to lead her from semibarbarism into the ranks of civilized powers. Italy was a geographical expression covering a multitude of petty states.

Of all the peoples of Europe, only the French and the English possessed the power, the energy, the adventurous courage, the opportunity and the occasion for expansion across the Atlantic. The field and the prize were for them and for them alone.

Upon the throne of France was Henry the Fourth, the greatest of French kings. In the governing class of Frenchmen, political and religious, were the virile strength, the intellectual acumen, the romantic chivalry, the strong passions, the love of glory, the capacity for devotion to ideals, which were to make possible the rule of Richelieu, the ascendancy of Louis the Fourteenth, the political idealists of the Eighteenth century, the tremendous social forces whose outbreak in the French Revolution appalled the world, and the armies of Napoleon.

In England the reign of great Elizabeth had just closed. It was the England of Spenser and Shakspere and Bacon; of Cecil and Raleigh; of Drake and Frobisher. John Hampden and Cromwell and Milton were in their childhood. For four centuries since Magna Charta, Englishmen had become accustomed to the assertion of the individual rights of the citizen against arbitrary power. Since the repudiation of Roman supremacy over the national church by Henry the Eighth three generations had become wonted to the assertion of religious freedom. King James's translation of the

Bible was in progress and nearly completed. The deep religious feeling of the Puritan reaction against both Roman and royal episcopacy that was to cost Charles the First his life and James the Second his throne had already become a controlling motive among a great multitude of the English people.

From these two countries, each possessed of great powers, each endowed with noble qualities, proceeded the colonists who were to dispute for the possession of America. The French movement was in the main governmental, aristocratic, proceeding from state and church, designed to extend and increase the power, dominion, and glory of the king, to convert the Indians to the true faith, and to extend over them and over all the lands through which they roamed, and over all who should come after them and take their place, the same iron rule of conformity against which the Huguenots of France were vainly contending. The English movement was in the main popular, proceeding from the people of England who wished to escape either church or state at home and to find freedom in a new world for the practice of their religion or the pursuit of their fortunes according to their own ideas. Some of the English colonies braved the hardships of exile rather than conform against their consciences to requirements of practice and doctrine which the English church imposed. Some sought for fortune in the New World because the state had so distributed the property and so closed the avenues for advancement in England that they must needs seek opportunities elsewhere if at all.

For centuries the struggle between civil and religious absolutism on the one hand and individual liberty on the other were waged alike in France and England. The attempt to colonize America came from one side of the controversy in France and from the other side of the same controversy in England. The virtues of the two systems were to be tried out and the irrepressible conflict between them was to be continued in the wilderness.

For capable and efficient leadership, for farsighted and comprehensive plans, for clear understanding of existing conditions and prevision as to the future, for conspicuous examples of heroic achievement and self-devotion, the palm must be awarded to the French over their English competitors. There are few chapters in history so full of romantic interest, so compelling in their demands for sympathy and admiration, as the record of the century and a half that began with the wooden fortress of Champlain under the bluff at Quebec and ended with the fall of Montcalm on the Heights of Abraham.

The world owes many debts to France. Not the least of these is the inspiration the men of every race can find in the noble examples of such explorers as Niccolet and Joliet and La Salle; such leaders as Champlain and Frontenac and Duquesne and Montcalm; and such missionaries as Le Caron and Breboeuf and Marquette. They strove for the execution of a great design, holding hardship and suffering and life of little account in their loyalty to their religion and their king. With infinite pains they won the friendship of the Indians of the St Lawrence and the far Northwest; they carried the flag of France to the mouth of the Mississippi; they drew a cordon of military posts up the St Lawrence across to the Mississippi and down to the Gulf, well designed to bar the westward advance of the English colonies, to save the great West for their race and thence to press the English backward to the sea. Their soldiers were, as a rule, better led, better organized, and moved on more definite and certain plans than the English. Occasionally some born fighter on the English side would accomplish a great deed, like Pepperell at Louisburg, or some man of supreme good sense would bring order out of confusion, as did Franklin and Washington, but as a rule colonial legislatures were slow and vacillating, colonial governors were indifferent and shortsighted, and colonial movements were marked by a lack of that definite responsibility, coupled with power, so essential to successful warfare.

Fortunately for England, between the two parties all along the controlling strategic line from this Lake Champlain to the gateway of the West at Fort Duquesne, stretched the barrier of the Long House and its tributary nations. They were always ready, always organized, always watchful. They continually threatened and frequently broke the great French military line of communication. Along the whole line they kept the French continually in jeopardy. Before the barrier the French built forts and trained soldiers — behind it the English cleared the forests and built homes and cultivated fields and grew to a great multitude, strong in individual freedom and in the practice of self-government. Again and again the French hurled their forces against the Long House, but always with little practical advantage. At one time De Tracy, the Viceroy, burned villages and laid waste the land of the Iroquois with twelve hundred French soldiers. At another De La Barre, the Governor, with eighteen hundred; at another De Nonville with two thousand; at another Frontenac with six hundred; at still another, Frontenac

with a thousand. Always there came also a cloud of Algonquin allies. Always the Iroquois retired and then returned, rebuilt their villages, replanted their fields, resumed their operations and in their turn took ample revenge for their injuries.

So, to and fro the war parties went, harrying and burning and killing, but always the barrier stood, and always with its aid the English colonies labored and fought and grew strong. When the final struggle came between the armies of France and England, the French had the genius of Montcalm and soldiers as brave as ever drew sword; but behind Wolfe and his stout English hearts was a new people, rich in supplies, trained in warfare and ready to fight for their homes. South Carolina, the records show, furnished twelve hundred and fifty men for the war; Virginia, two thousand; Pennsylvania, two thousand seven hundred; New Jersey, one thousand; New York, two thousand six hundred and eighty; New Hampshire and Rhode Island, one thousand; Connecticut, five thousand; Massachusetts, seven thousand. It was not merely the army — it was that a nation had arrived, too great in numbers, in extent of territory, in strength of independent, individual character, to be overwhelmed by any power that France could possibly produce. The conclusion was foregone. A battle lost or won at Quebec or elsewhere could but hasten or retard the result a little. The result was sure to come as it did come.

In all this interesting and romantic story may be seen two great proximate causes of the French failure and the English success; two reasons why from Quebec to the Pacific we speak English, follow the course of the common law, and estimate and maintain our rights according to the principles of English freedom.

One of these was the great inferiority of the Indian allies of the French, and the great superiority of the Indian allies of the English; the effective and enduring organization, the warlike powers, of the Iroquois, and their fidelity to the "covenant chain" which bound them to our fathers. The other cause lies deeper: It is that peoples, not monarchs, settlers, not soldiers, build empires; that the spirit of absolutism in a royal court is a less vital principle than the spirit of liberty in a nation.

In these memorial days let there be honor to Champlain and the chivalry of France; honor to the strong free hearts of the common people of England; and honor also to the savage virtues, the courage and loyal friendship of the Long House of the Iroquois.

THE INDIAN VILLAGE NUNDAWÄO

NUN-DA-WÄ'-O, THE OLDEST SENECA VILLAGE

BY D. D. LUTHER

Ge-nun-de-wa, or Bare hill, on the east side of Canandaigua lake 5 miles from the head, is the legendary birthplace of the Seneca nation, the place where the Nun-dá-wä-o-nó or "Great Hill people" of the Iroquois Indians held their first council fire. Its summit is 865 feet above the lake.

At the south is Vine valley, separating it from a larger hill that rises 1200 feet from the lake with a steep acclivity and extends into the swamp half a mile beyond the head.

This larger hill is 4 miles long and 3 miles broad at the base, the deep valley of West river lying on the east side.

Though its summit is not the highest in this region, its configuration and surroundings make it, perhaps, the most prominent feature in the topography of the Canandaigua lake valley and its name Nun-da-wä'-o (Great Hill) strikingly appropriate. Canandaigua lake extends in a southwesterly direction about 6 miles beyond the present head of the lake.

For 2 miles from the head the bottom of the valley is a sparsely timbered, flaggy swamp through which flows Naples creek, the principal inlet of the lake, a deep sluggish stream 30 to 50 feet wide, navigable for rowboats for about 2 miles.

Next south of the swamp lie the "flats," an alluvial plain nearly a mile wide at the north end but coming to a point at the foot of Hatch hill directly opposite the village of Naples. Here the Naples creek leaves the base of the hill and takes its course diagonally across the valley for 1⅛ miles, thence northward along the foot of West hill to the swamp. A smaller stream takes the drainage from Hatch hill and flows along the east side of the valley for 1½ miles, then, after joining the Parrish gully stream crosses the flat to the main inlet not far from the south edge of the swamp, the two streams thus nearly inclosing an area of rather more than a square mile of land.

Indian relics are common on a large part of this area, and in two localities their abundance and character are evidences of long or repeated occupation as the site of a village of considerable size.

Conditions were exceedingly favorable for the Indians mode of life here. Except the continuation of the valley to the lake at

the north and the West river valley at the northeast, the flats are entirely surrounded by great hills, Hatch hill at the east, Knapp hill and Pine hill at the south, and High point, West hill and Gannett hill on the west are all 1300 to 1500 feet higher than the bottom of the valley, while passes between them at the hight of about 700 feet make neighboring valleys accessible.

The villages were not only sheltered from the winter storms by these hills; they were also so secluded that, though in the heart of the Seneca country and on the principal trail leading from Kanadesaga to the Cohocton and Canaseraga valleys, neither De Nonville's invasion of their territory in 1687 nor Sullivan's punitive raid in 1779 reached them.

The slopes of the hills, cut by numerous gullies and large ravines, and the swamp must have afforded game in abundance. The lake was easily reached by canoe down the inlet or along the foot of West hill, while nuts and berries and the sugar maple trees grew everywhere.

The soil, a dark mellow, rich alluvium, required but little cultivation to produce large crops of fruit, corn and vegetables, and several large springs furnished an ample supply of pure water.

Little can be ascertained in regard to the Indian occupation of this valley previous to the advent of the white settlers. On Pouchot's map of 1758 the number 28 indicates a village here with the name *Kanentage*. Dr Beauchamp says this means "Canandaigua, but at the wrong end of the lake." The dotted line showing Pouchot's route, however, passes through this valley [*see* N. Y. State Mus. Bul. 78].

Lewis H. Morgan in *The League of the Iroquois* 1851, describes the separation of the Iroquois into the Five Nations and says [page 6, Dodd, Mead & Co. 1904]: "The Cayugas and Senecas were many years united and resided upon the Seneca river, but one band of them having located upon the east bank of Cayuga lake grew up in time to a distinct nation; while the residue, penetrating into the interior of western New York, finally settled at *Nun-da-wä'-o* at the head of Canandaigua lake and there formed the nucleus of the Seneca nation. The Onondagas have a legend that they sprang out of the ground on the banks of the Oswego river; and the Senecas have a similar legend that they sprang out of the ground at Nun-da-wä'-o." On page 48 he says: "The Senecas called themselves the Nun-da'-wä-o-no' which signifies the great hill people.' Nun'-da-wä, the radix of the word, means 'a

great hill' and the terminal syllables 'o-no' convey the idea of 'people.' This was the name of their oldest village, situated upon a hill at the head of Canandaigua lake near Naples where, according to the Seneca legend, they sprang out of the ground." On the map accompanying the book, the site of the village of Nun-da-wä'-o is located precisely on that part of the Naples flats where evidences of the former existence of an Indian village are now found in greatest profusion.

Though flints are occasionally found on the hillsides, and very rarely a pestle, nothing to indicate an Indian village has yet been discovered in the region about the head of Canandaigua lake except in the valleys.

The late Miss Jane Mills, who during many years collected material for a history of Naples, getting much of her data from descendants of the pioneer settlers, says in her unpublished manuscript: "they (the first comers) arrived at the village of Nun-da-wä'-o."

French's *Gazetteer* of New York, page 407, note, says: "Naples was called by the Indians Nun-da-wä-o."

There is not much room for doubt that the village on the flats was the traditional Nun-da-wä-o, but it was not unusual for Indian villages to have two or more names, and we find that the pioneers and their descendants have preserved another name for this one. This valley was in the central part of the Phelps and Gorham Purchase of 1787, the Indian title to which was extinguished in 1788. In 1789 the present township of Naples was sold to a company of Massachusetts men and surveyed by a party of six men from that state. So far as can be ascertained these were the first white men, except Pouchot, who arrived at this Indian village.

In an address before the Naples Lyceum in 1831 the speaker, whose name is not known but who claimed to have derived his information from one of these surveyors, said: "They entered the inlet that flows through this valley and came on shore at the old Indian landing 2 miles below the village of Naples. Here they found an Indian settlement which in the dialect of the natives was called Ki-an-da-ga, said to mean 'between the hills.' There resided here at this time 30 to 40 families embracing about 100 souls and from the contiguity of ancient fortifications[1] it may be presumed that these natives had been lords of the soil from time immemorial."

[1] Nothing more is known of fortifications here.

The late Seymour H. Sutton of Naples published in 1851 a series of articles entitled the *Annals of Naples* in which he states that the first party of settlers came up the lake on the ice in February 1790 and "moved up the inlet till they arrived at a wigwam where they sought the hospitality of the Indian owner, while the cattle were turned out to feed on the tall dry grass that grew in the valley of Koyendaga.

On the succeeding morning they saw the smoke of 40 wigwams against the sky and the Indians began to assemble in small groups to view the white intruders. *Hiotonta* in the native dignity of a chief of gigantic stature and graceful manners, and *Canesque* (Ka-nes-ka?) the tall and venerable ex-chief of a hundred winters, also comes to look.

'The lofty hills,' says Parrish (one of the first settlers) 'on either side of *Koyendaga* were so destitute of timber that a deer might plainly be seen from one extreme end to the other, even to the very top.'

At this time the Indians cultivated a large portion of the land along the creek. The flats were interspersed with patches of wild plum and the dry land sparsely covered with black walnut and sugar maple trees."

Although the Indians had surrendered all claim to the land, they had reserved the right to hunt and fish here for 20 years, and many of them remained and appear to have lived on the most amicable terms with the settlers.

Even after they had removed to the reservation on the Genesee river, they returned annually during the hunting season. The late Col. N. W. Clark could remember seeing their group of wigwams near where the Methodist church now stands in Naples village. They assisted the first settlers in their construction of a hominy block or stump mortar, the pestle or pounder of which was operated by aid of a spring pole, and took their turn in the use of it.

Sutton relates some later incidents connected with the Indians here: "They were in the habit of visiting Squakie hill near the Genesee river. Canesque was there and, dying of old age, he desired to be brought back to *Koyendaga* to die and be buried with those he loved. In the winter of 1794 two Indians, from sympathy and kindness, conveyed the aged chief on a sled over 40 miles to the place where he chose to die. The whites administered to his comfort till he died. . . . His funeral was

the first attended here by the settlers." The place of his burial is not known. "In the fall of 1796 several young Indians joined the settlers in a panther hunt in a large ravine south of the settlement, now known as 'Tannery gully.'

The winter of 1797–98 was uncommon for the depth of snow. The Indians could not hunt even with snowshoes and were reduced to the verge of starvation and were frequently supplied with provisions by the settlers. On a certain day the Indians assembled at a point now in the southern part of the village of Naples and after a basswood tree had been cut down the tall chief *On-is-o-ti-ka* mounted the stump. The Indians silently surrounding the chief with their rifles pointing up as in an act of presentation, remained in silence while the chief addressed them with an eloquence and dignity of manner which seemed to impress them and arouse their feelings. At the close of this speech the report of the rifles told the end of the conference and the Indians quietly departed to their homes.

In the autumn of 1798 the Indians held a grand festival on the higher ground a mile southwest of their larger village, having assembled from a great distance, all dressed in their neatest manner. A large fire had been built the night before. The Indians stood in small groups. The squaws were sitting quietly on the ground, the little papooses lashed to the board were set up against the trees. At a given signal the Indians joined hands in one grand circulade (*sic*) and danced around the fire, rattling small sticks, beating small drums and singing in a loud monotonous tone, giving great emphasis to the last word of each strain. The squaws were in their best attire, with fur hats with silver bands and with numerous bells and hawks' claws, beads and shells hanging from their blankets. The Indians had many gaudy trinkets and trappings peculiar to their taste and their clinking sound seemed to harmonize with their wild music. The chief Onisotika presided."

At the time Mr Sutton wrote the *Annals* there were living in the vicinity several sons and daughters of the pioneers and it was from them that he derived his information.

In a centennial address delivered in 1889 by Hon. E. B. Pottle, grandson of one of the first settlers, he described their journey over the ice on the lake and up the inlet "until, as they in after years said, they reached the lower Indian village. This was on what is now my farm, the upper Indian village being south of the road across the flats on lands now owned by Ira C. Williams."

The localities specified are approximately those where relics have recently been found in greatest profusion.

The lower village which apparently was much the larger, was not situated directly upon the banks of the inlet but mainly along the east side of the outlet of a large spring now known as the "Barber spring" and extending east and south to the vicinity of other springs.

The upper village was about ¾ mile further south and bounded on the east by the "old creek" but appears not to have extended to the Naples creek on the west. All except about 1 acre of this site is covered by a heavy turf and its full extent is not known.

Evidences of occupation have also been found on the east side of the "old creek" and on the north side of the alluvial cone at the mouth of Parrish gully and west of Naples creek on the higher ground in the vicinity of the old cemetery.

If any place was specially set apart by the Indians as a burying ground the locality is not certainly known though it is traditional that the old cemetery in the northern part of the village of Naples was an "Indian burying ground" before the whites appropriated it.

Skeletons supposed to be those of Indians have been exhumed near Academy street and one of a man buried in a sitting posture and facing toward the east was found in 1907 in "Woodchuck knoll" a little south of the upper Indian village. No relics have been found in graves here.

The former existence of "an Indian village on the flats" has been pretty generally known to Naples people, but it has never been an object of special attention or interest until recently the writer has undertaken to ascertain, as nearly as possible, the precise location of the two villages as shown by the distribution of the relics and to collect whatever might be found that bore clear evidence of having been fashioned or used by those who dwelt in them.

When it is remembered that the inhabitants were not driven away from their homes hurriedly but had abundant time in which to remove whatever they considered of value; that the land has been under more or less vigorous cultivation by the whites for 120 years, and that less than ⅕ of the area can now be satisfactorily searched, the remaining 4/5 being covered by heavy turf, the quantity of the material collected, if not the quality, is of some interest.

The material consists of stone mortars or anvils, pitted hammer stones, pestles, sinkers, hoes, celts, arrows and other flint articles, pottery in fragments and stems of pipes, etc.

Mortars or anvils. These are blocks of gray sandstone from the local Portage flags, roughly dressed to a nearly circular shape 8 to 12 inches in diameter and about 2 inches thick, weighing 7 to 15 pounds. On one side a shallow cup-shaped depression has been picked out by hard blows with a sharp instrument, leaving a rough surface. The other side is usually slightly concave and smoothly polished, probably by use of a muller in pulverizing substances very finely. 21 of these were found, 18 in the vicinity of the lower site, one at the upper, one half a mile east of the lower site and one half a mile southwest. Many broken fragments occur.

Hammer stones. These are mostly round or oval flattened drift pebbles from the nearby creek bed weighing 1 to 4 pounds. Over 200 of these were found, 145 at or near the lower site, 54 at the upper, one half a mile east and another half a mile southwest of the lower site; 33 of these show by the battered condition of their ends and sides that they have been used as veritable hammers against some hard substance, possibly to pulverize the rock mixed with clay in the process of manufacturing pottery. 18 are granite or schist, the others being of hard quartzite or sandstone. The pits on these are large, shallow in proportion to size and worked smooth. The pits aid very much in getting a firm and easy grasp of the implement. 4 are flat blocks of sandstone 1½ to 2 inches thick and have a funnel-shaped pit on one side only an inch in diameter and ½ inch deep. The pit on one block shows that it was made by a rotary drill. The other specimens are all sandstone, mostly Portage or Medina, and in shape range from globular to irregularly angular. The pits also show a variety of shapes, some being large and worked out smoothly at the expense of considerable labor, the other extreme being those made by a half dozen hard blows with a sharp pick. 5 have two pits on one side.

While the most of these pitted stones would be serviceable in cracking nuts, grinding corn and similar substances, some of them are not at all suitable and evidently were not designed for such use.

Pestles. One 24½ inches long, very roughly dressed. One 14 inches long, flattened and slightly curved; one 12 inches long, 1 ½

inches in diameter, very symmetrical and polished; one 6 inches long, very crude, and fragments of 9 others, were obtained.

Sinkers. These embrace 71 flat pebbles of sandstone 2 to 4 inches in diameter and ¼ to ⅜ inches thick with two notches opposite each other on the edge.

Hoes etc. 22 thin pieces of sandstone 3 to 6 inches across and ½ to ¾ inches thick with the edges on one or more sides chipped thin, were found. Some of these were doubtless hoes, others may have served as axes.

Pottery. Fragments of clay vessels are very abundant at the lower site where the subsoil is a fine plastic clay quite suitable for the potter's use. 350 fragments 1 to 3 inches across and ⅛ to ½ inch thick were collected, all of which show surface ornamentation and 30 or more of them that of the rims. Pottery fragments are very rare at the upper site.

Parts of 9 pipe stems and of two bowls, one of the latter of stone, the others of clay, were found.

Flints. Those found on the sites consist of 26 arrow points entire, 20 nearly so and 20 others much broken, or spoiled in making. Also 4 perforators or drills, all with points broken off. A small curved knife, a small gouge, and a quart of chips or flakes. These are very abundant.

The arrows are all small and triangular in shape. Except one, which is translucent white quartz, they are common dark to light chert, such as occurs in layers and nodules in the Onondaga limestone. The only flint article found on the sites that has a stem is one of the perforators, though many stemmed arrows and spears have been found on the higher ground south of the sites, specially in the vicinity of a large spring near the railroad station in Naples and another half a mile south of the village.

Besides the above named articles there were found 2 celts, 2 stone balls, 3 stone disks and a few others that show artificial shaping for some unknown purposes.

Mortars, pitted stones, sinkers and flints similar to those above described were found on a small site near the West river bridge, 3 miles northeast from the village on the flats, where the first white settlers in 1797 found an Indian village composed of a few wigwams.

Like that of all the New York Indian nations, the early history of the Senecas is buried under legends that, although apparently purely mythical, may be not only allegorical but traditional as well and containing germs of real history.

The several versions of the legend concerning the origin of this nation all agree in locating this event in the region about the south end of Canandaigua lake.

To those who are acquainted with the topography of this region it would not be an overtax on credulity to believe that a band of Indians wishing or compelled to emigrate from their home on the Seneca river, and finding their way toward the west barred, possibly by hostile tribes, should take their course toward the southwest, through the West river valley and on arriving at this rich and spacious but sheltered and secluded intervale among the great hills, should actually make their first settlement and form their first village here.

And it is entirely reasonable to believe that, dwelling here in peace and plenty, their numbers would increase as the years passed, until having extended their occupancy down the lake shores and into the many warm valleys among the hills, the chief men among them should assemble on beautiful Genundewa, light their first council fire and bring into life a new nation with the significant and appropriate name Nun-da-wä-o-no, the People of the Great Hills.

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New York State Museum

JOHN M. CLARKE, Director

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2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 "
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 "
12 "
13 Entomology
14 Geology
15 Economic Geology
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